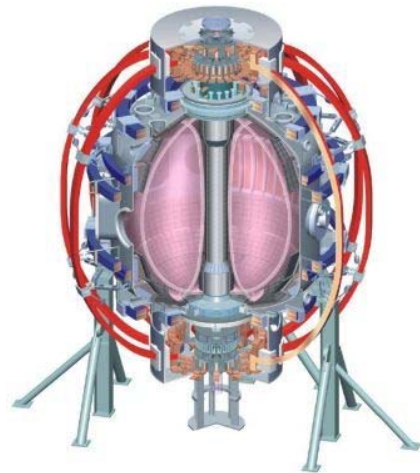


Neutral Beam Upgrade

Martin Denault

**NSTX Upgrade FDR
LSB, B318
June, 2011**



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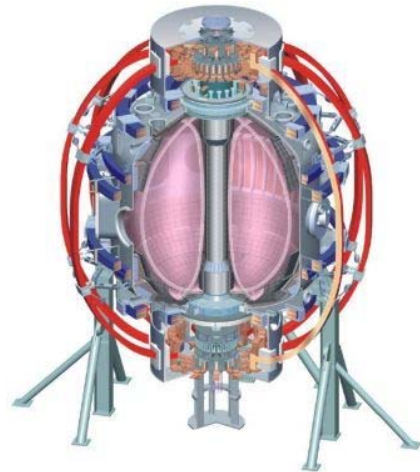
Introduction

- Refurbishment - 2440
- Relocation – 2425
- Beam Services - 2450
- Beam / TVPS Duct - 2480

Refurbishment

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Neutral Beam Refurbishment Scope

- Disassemble, inspect, refurbish, reassemble, and prepare NB parts for installation
- Replace seals and o-rings
- Replace thermocouples and wire
- Fabricate and install new ion dump
- Update calorimeter

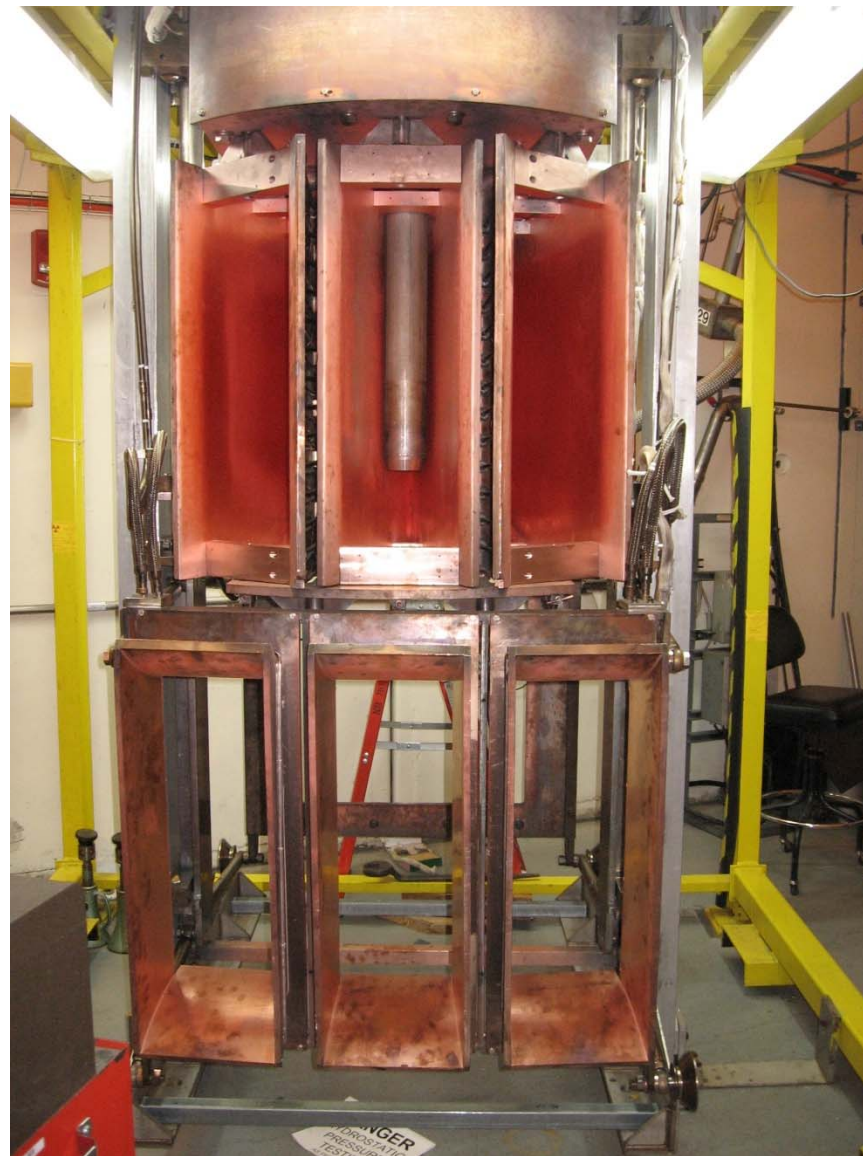
Refurbishment



New Ion Dump Fabrication



Updated Calorimeter

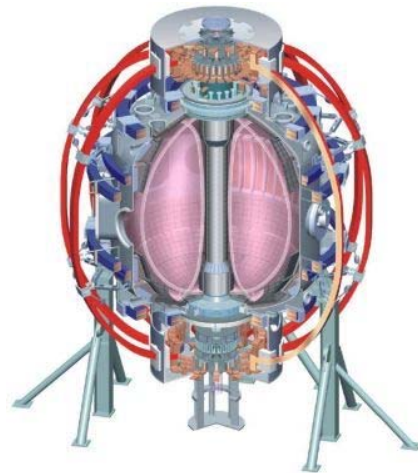


Questions?

Relocation

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Relocation Scope

- Move NB and ancillary equipment into NSTX test cell
- Fabricate legs for NBI - 2
- Align and install NBI - 2

Relocation Items

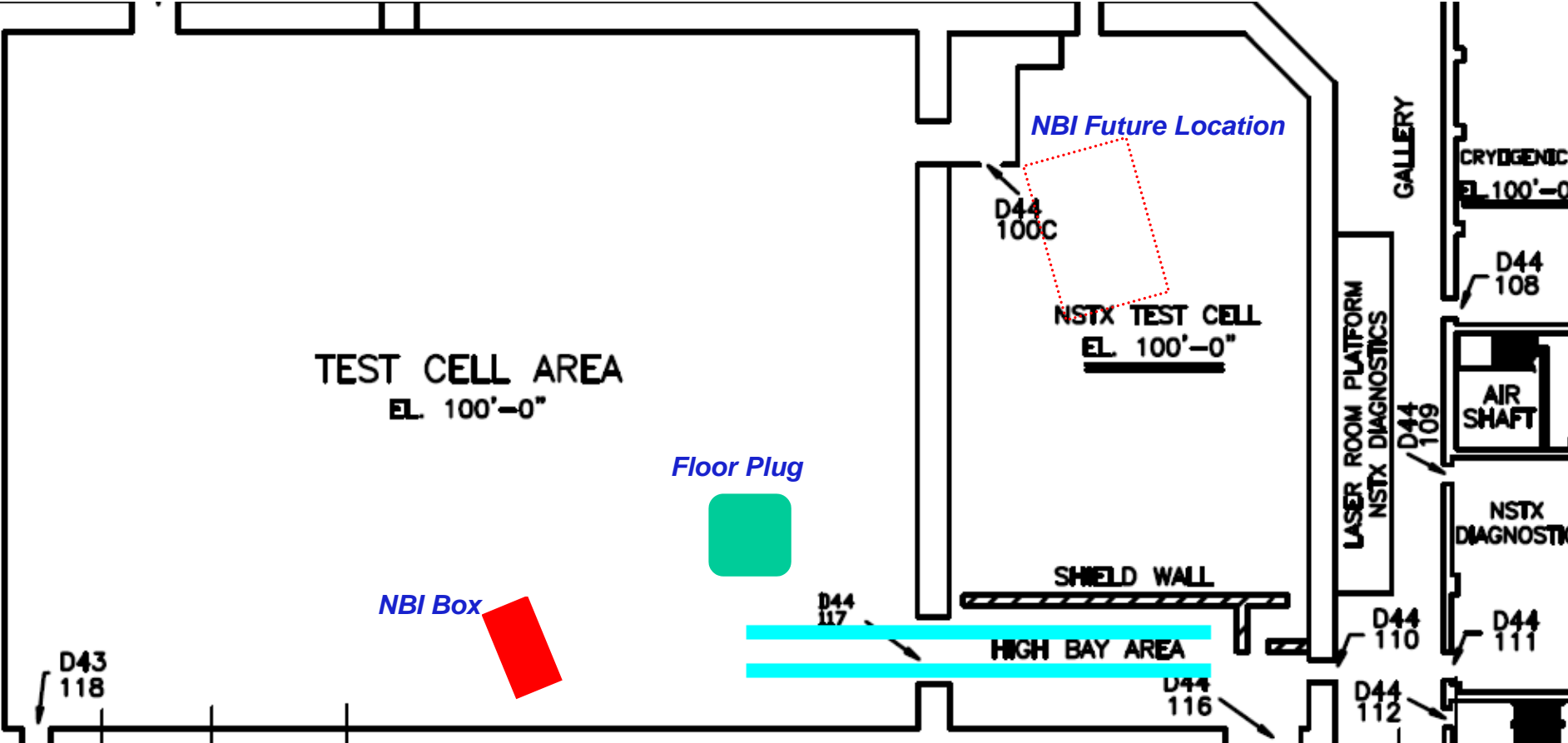
TFTR Test Cell

- Door Lintel
- Floor Plug (3 HVE's and 3 Transmission Lines)

NSTX Test Cell

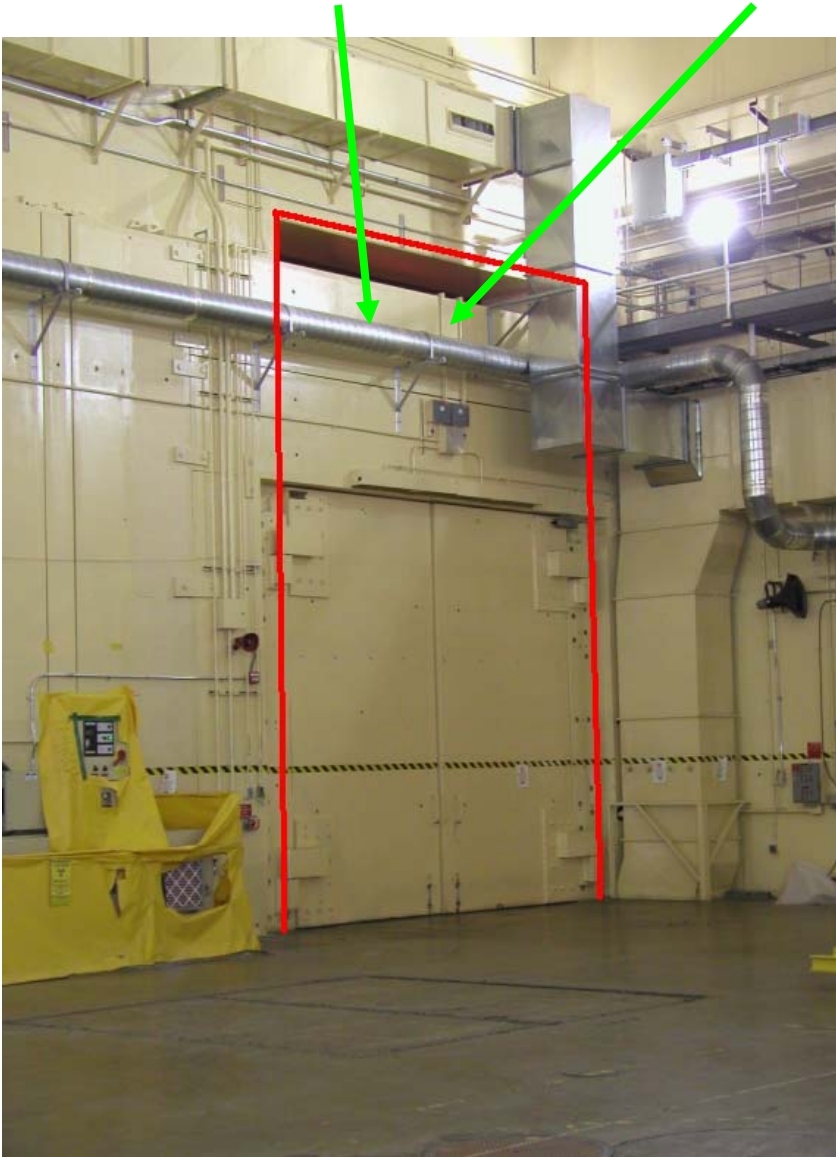
- NBI Box
- NBI Lid
- NBI Components (6)
- Source Platform
- Sources (3)
- High Voltage Enclosures (3)
- Labyrinth Shield Block

Relocation Path



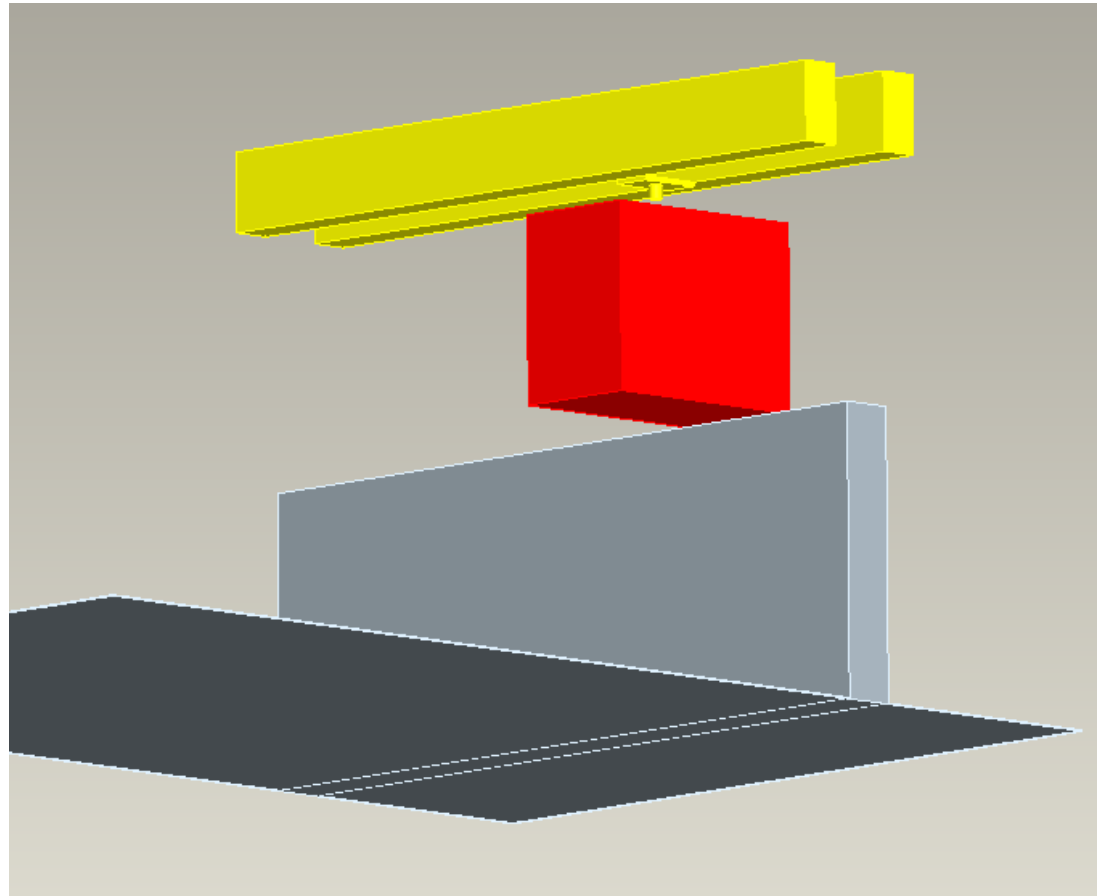
Clear Door

Remove duct work and lintels



Relocation

- Lift fixture design started for all components
- Re-entrant hook design for box



Legs for NBI BL2 identical to BL1

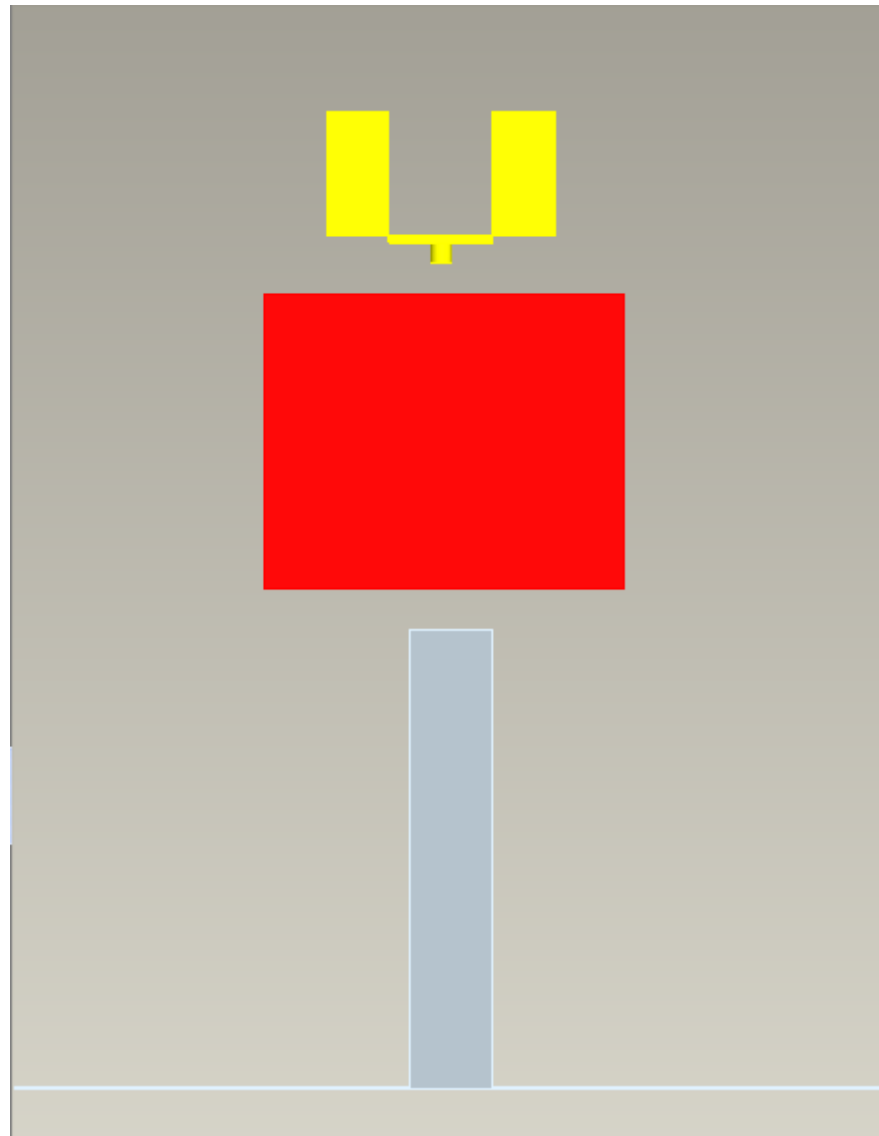


Calorimeter Lift Fixture

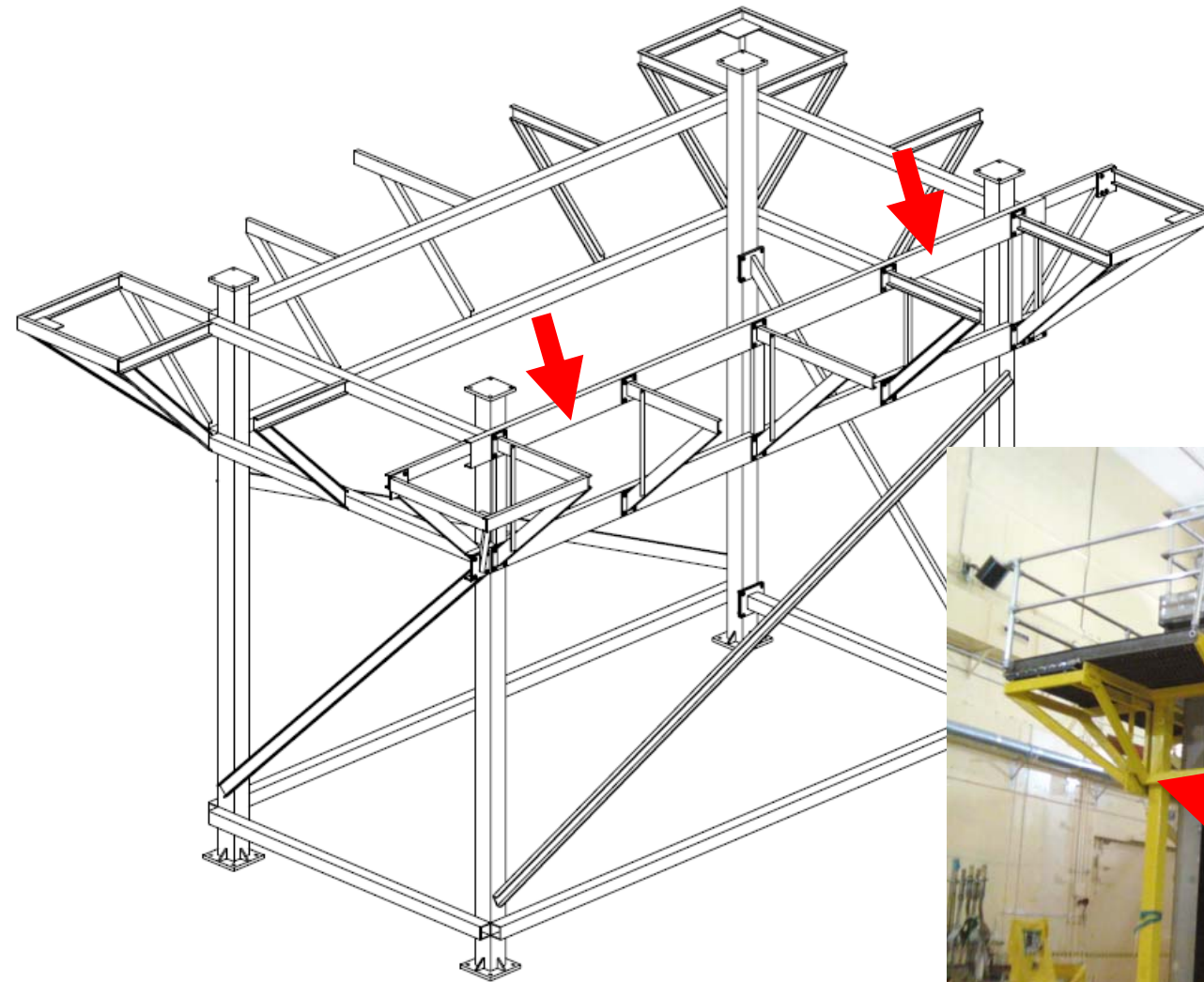


•*Extensions for updated design*

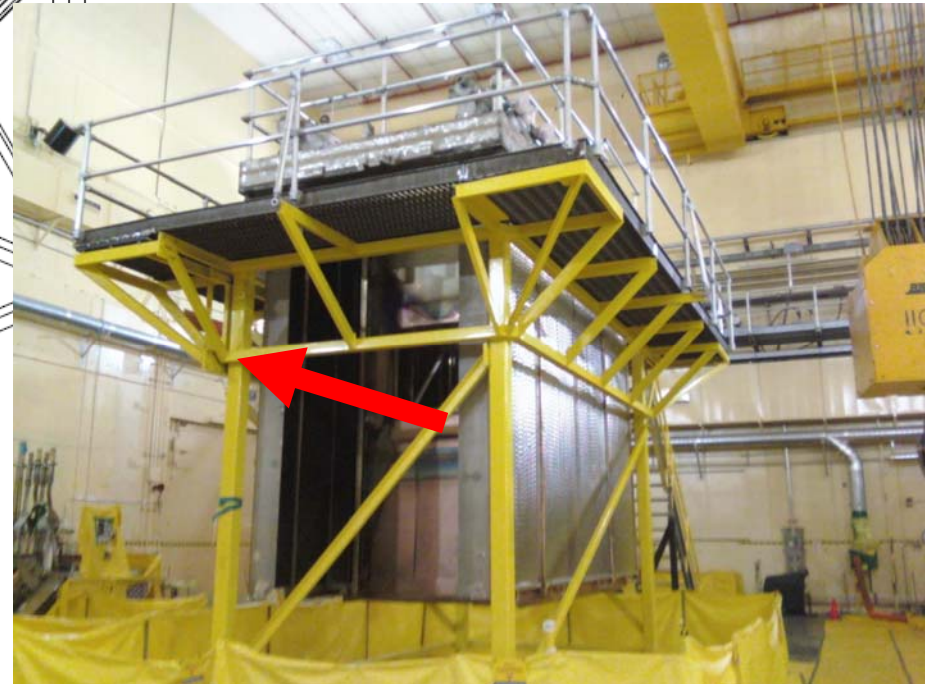
Neutral Beam Lift Fixture



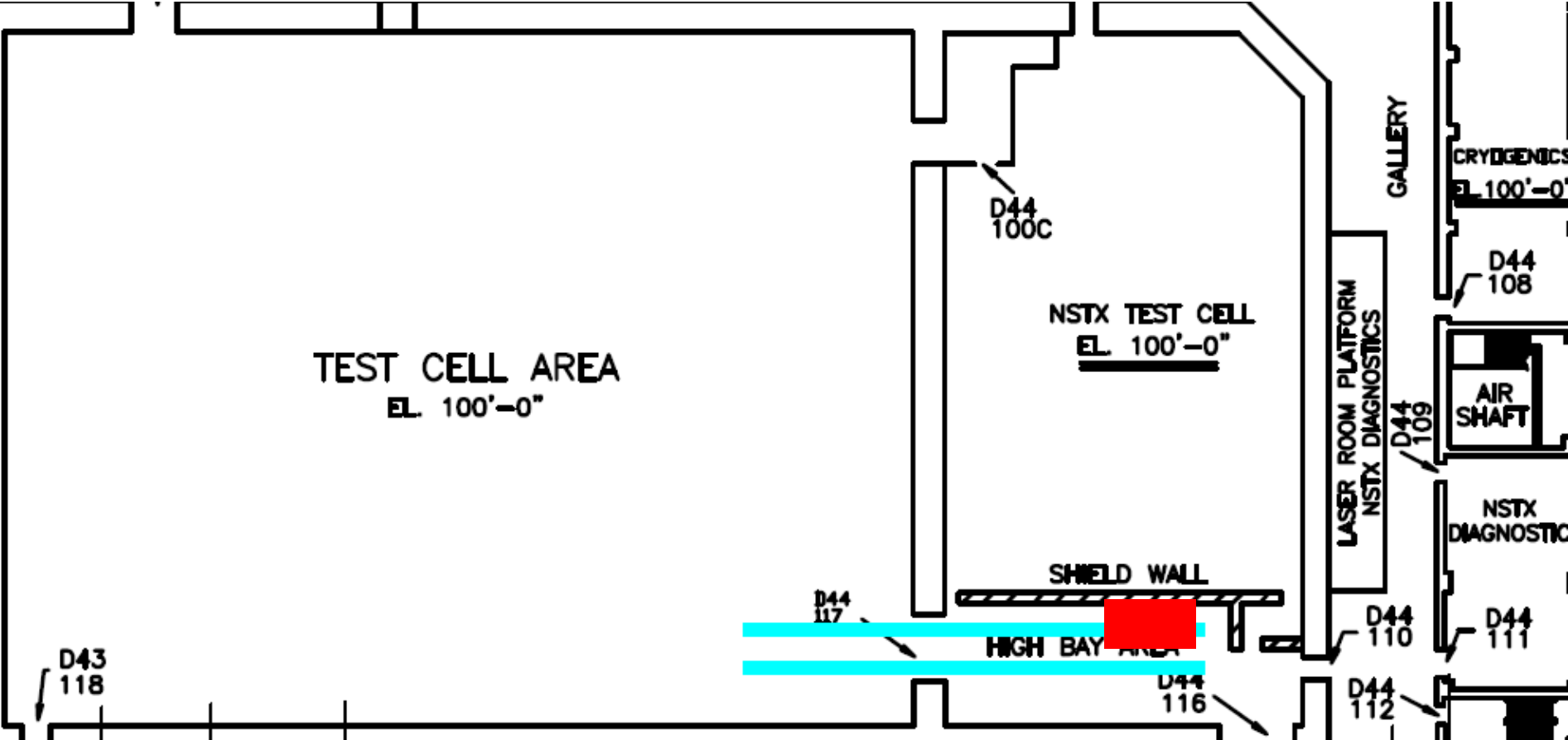
Lid Movement



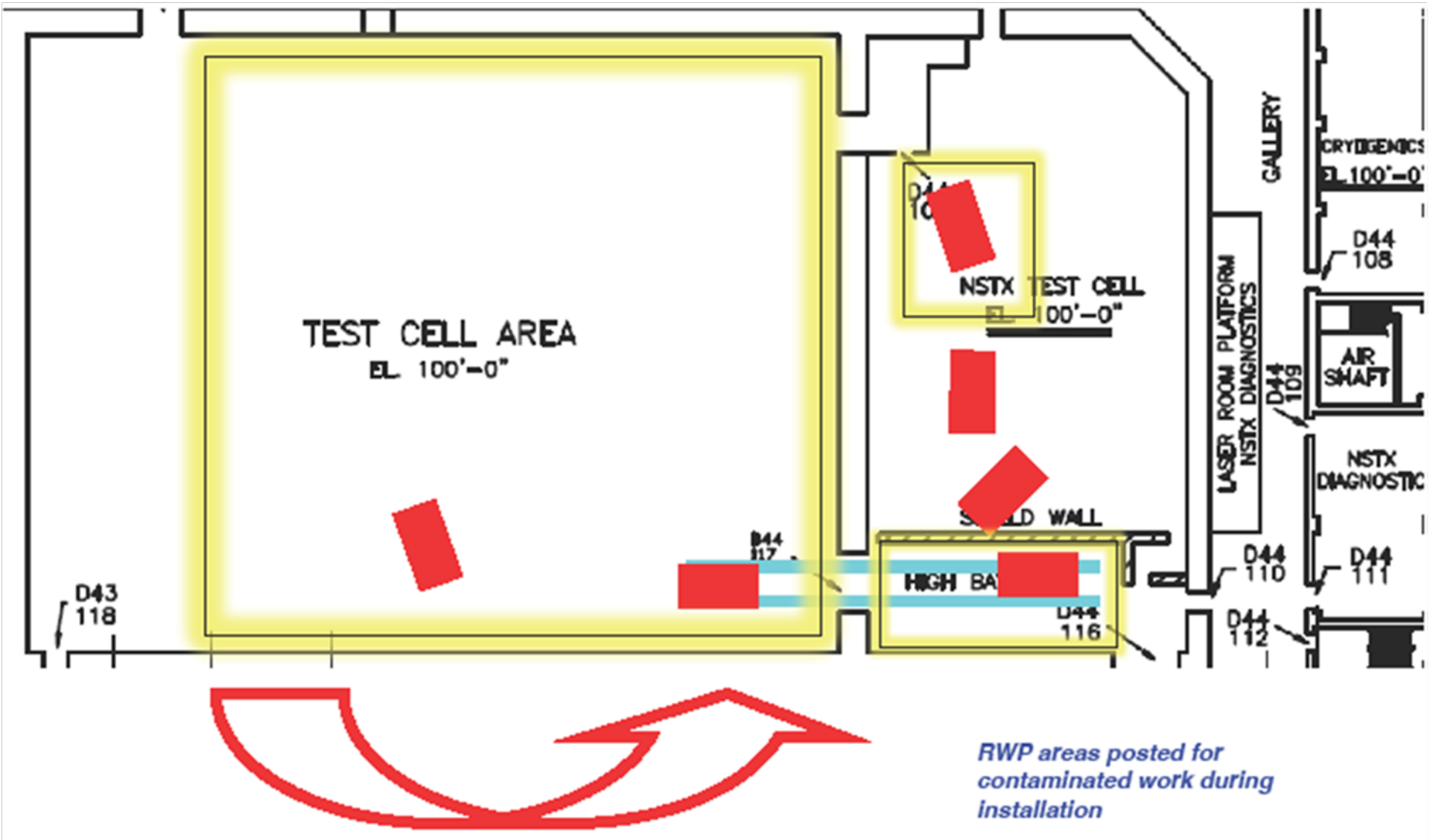
•Removable side



Lid Relocation Path



NBI Box Path

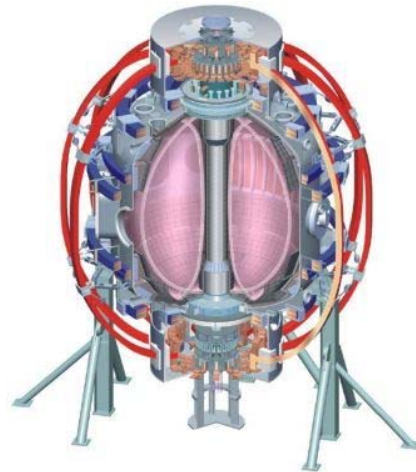


Questions?

Services

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Services Scope

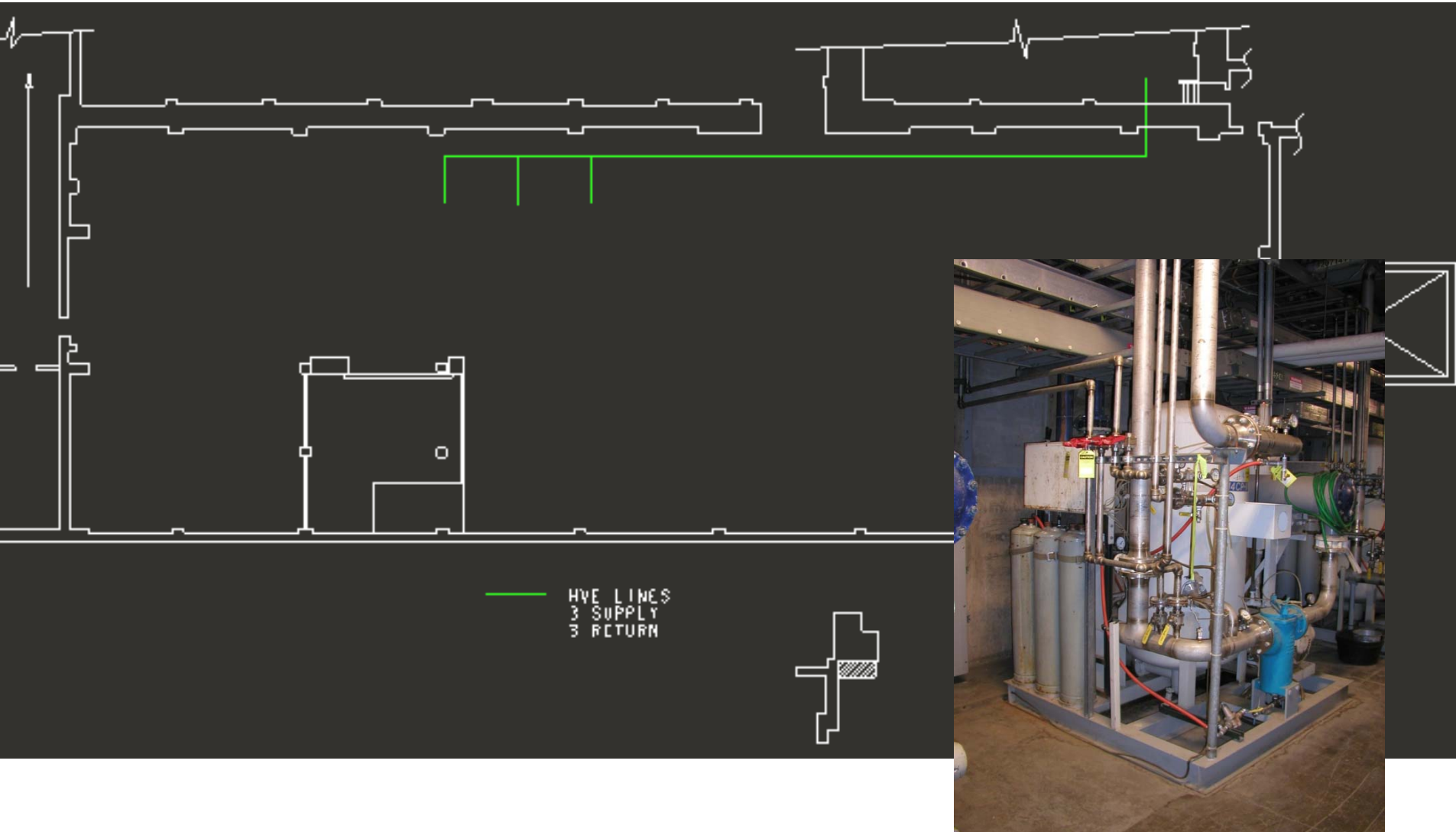
- Provide mechanical service to NBI – 2
- Install platform for NB and VV access

Beam Services

- High Voltage Enclosure Cooling Water
- Ion Dump Cooling Water
- Ion Source Cooling Water
- SF6
- Vacuum Backing
- Gas Injection System
- Liquid Nitrogen
- Liquid Helium

Pump Room HVE

NSTX Test Cell Basement (MER)

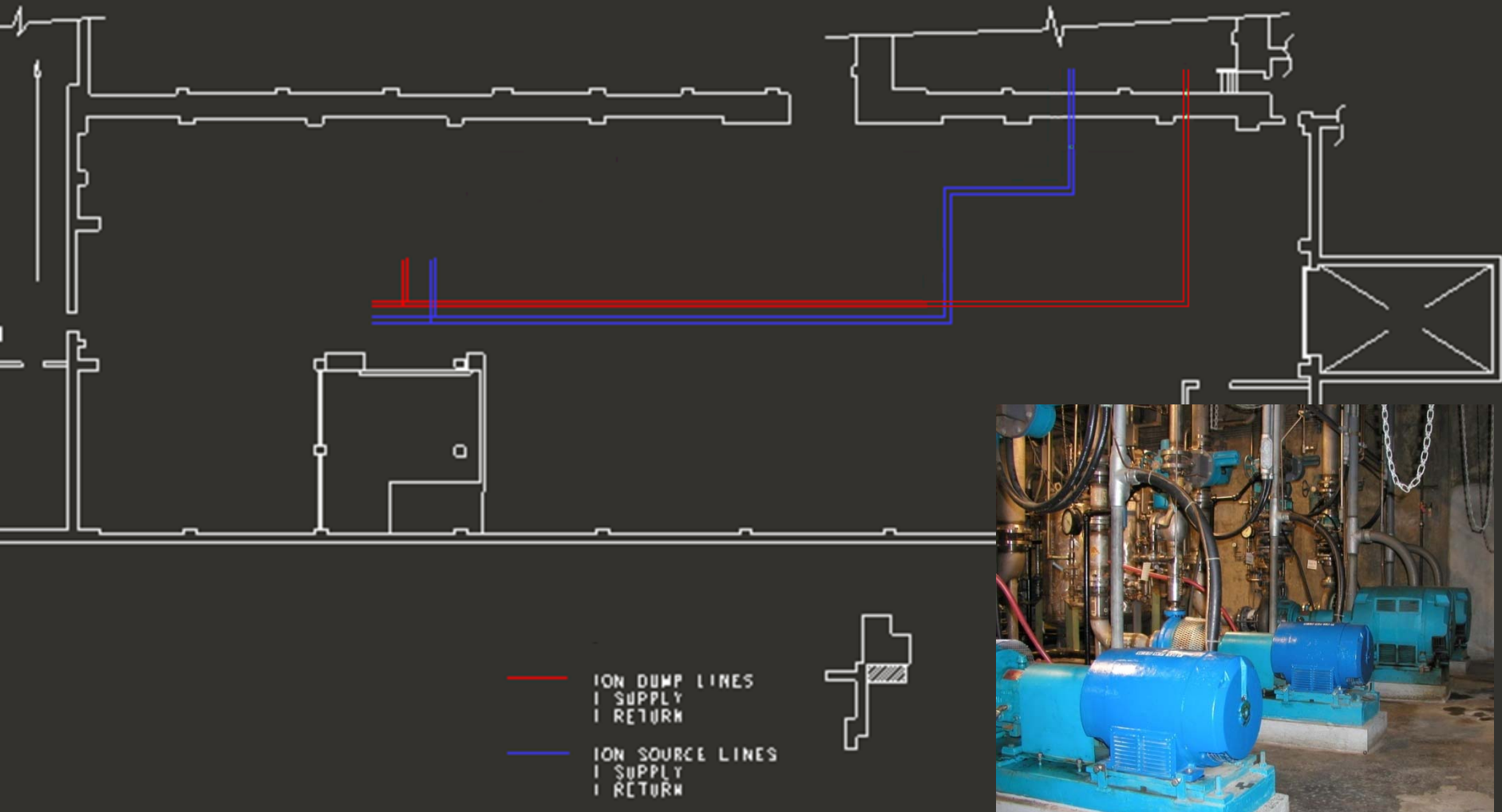


NBL2 HVE Penetration



Pump Room Source and Dump

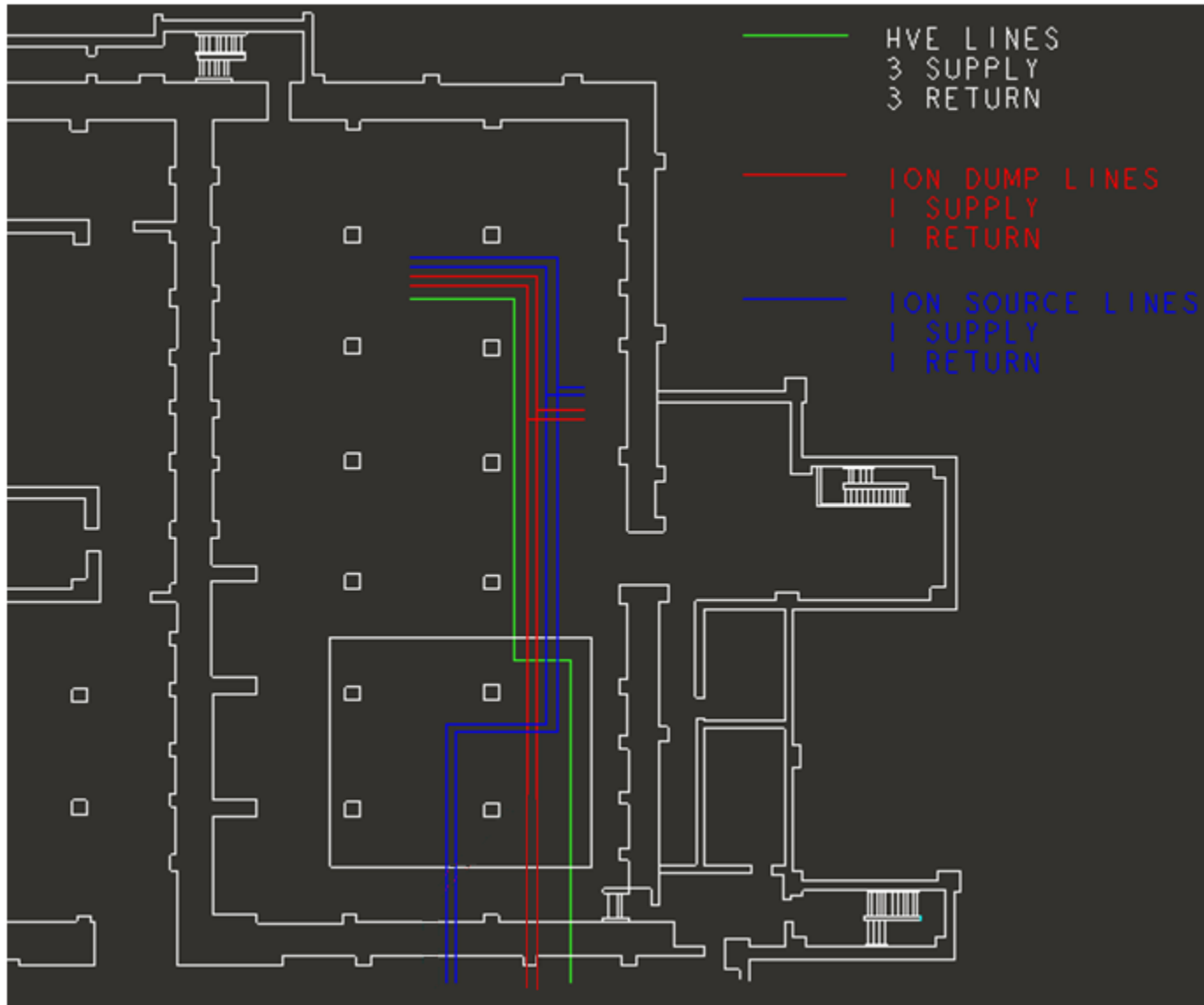
NSTX Test Cell Basement (MER)



NBL2 Penetrations



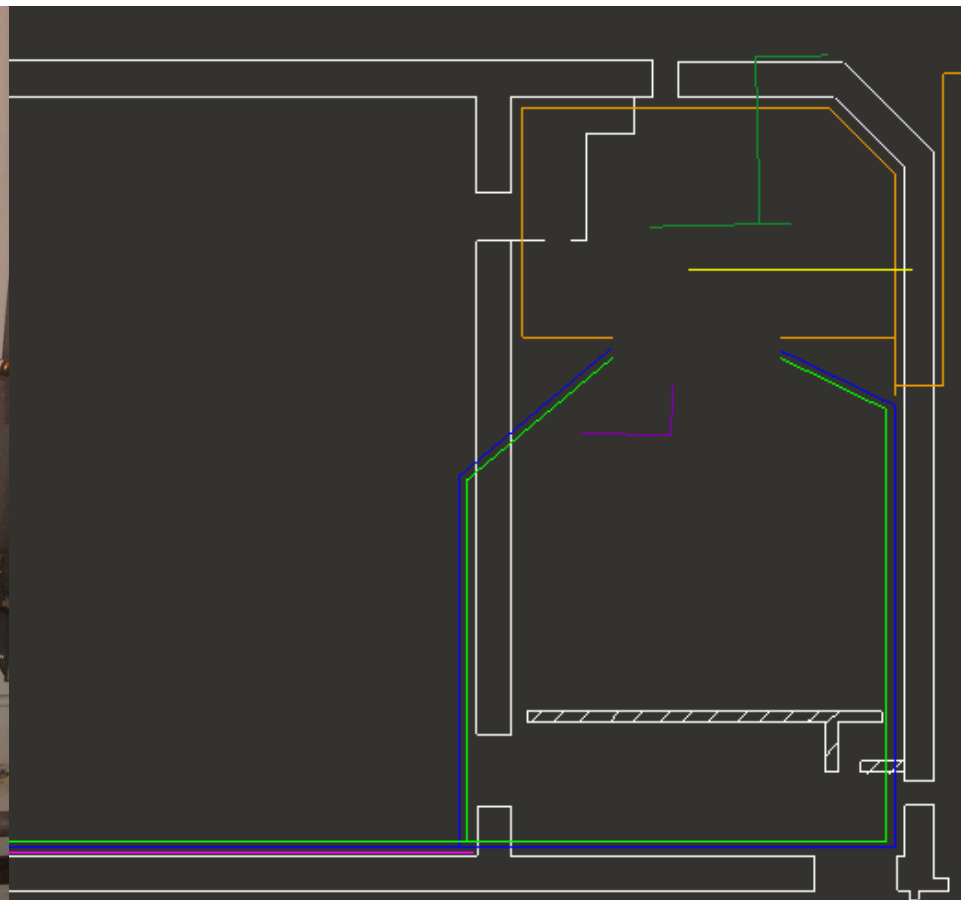
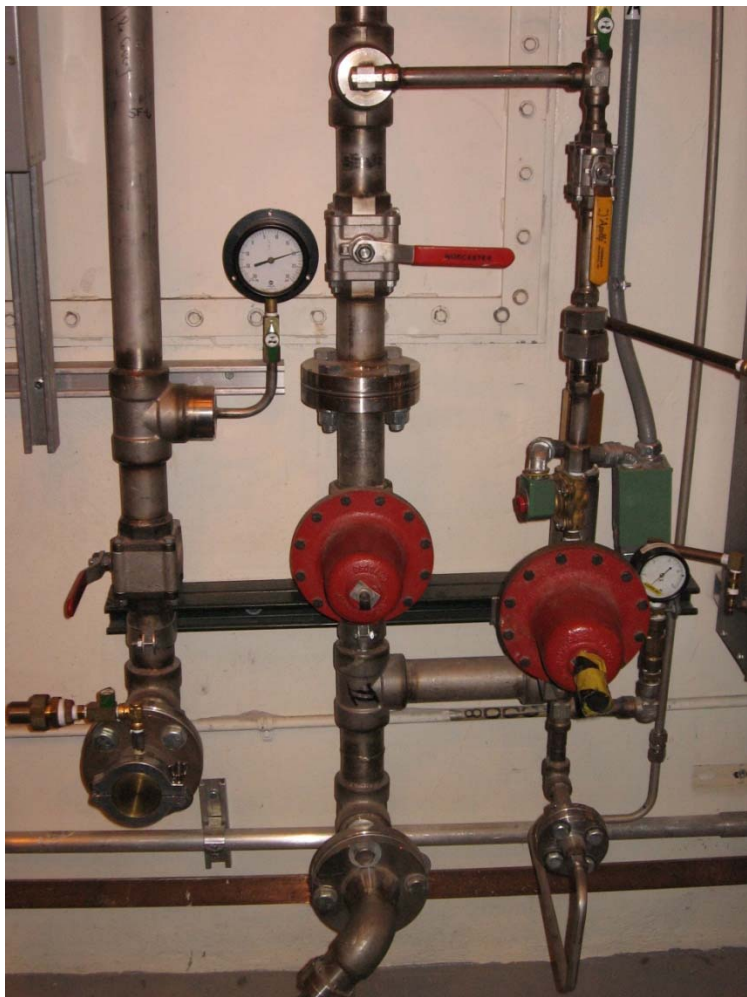
Mechanical Equipment Room (NSTX Test Cell Basement)



NBL2 Penetrations

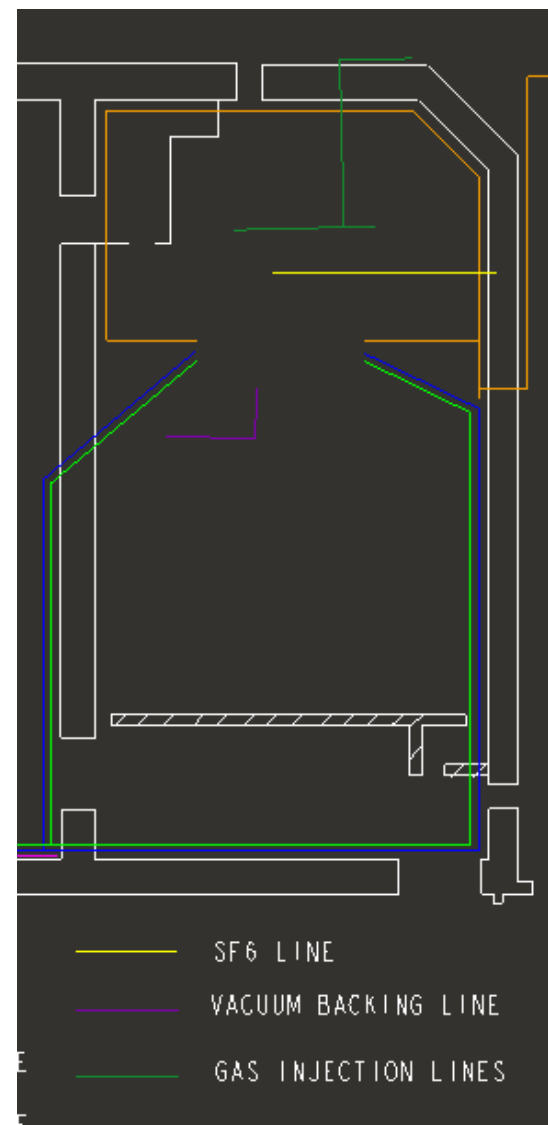
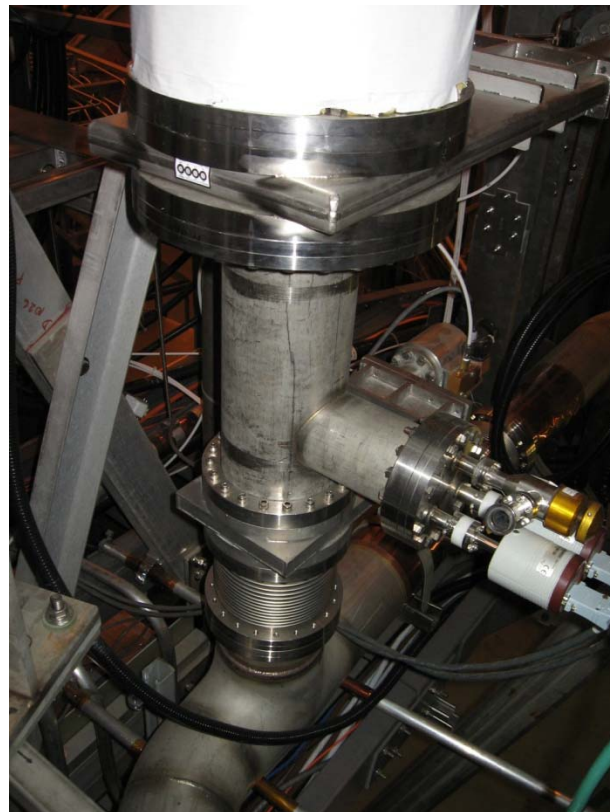
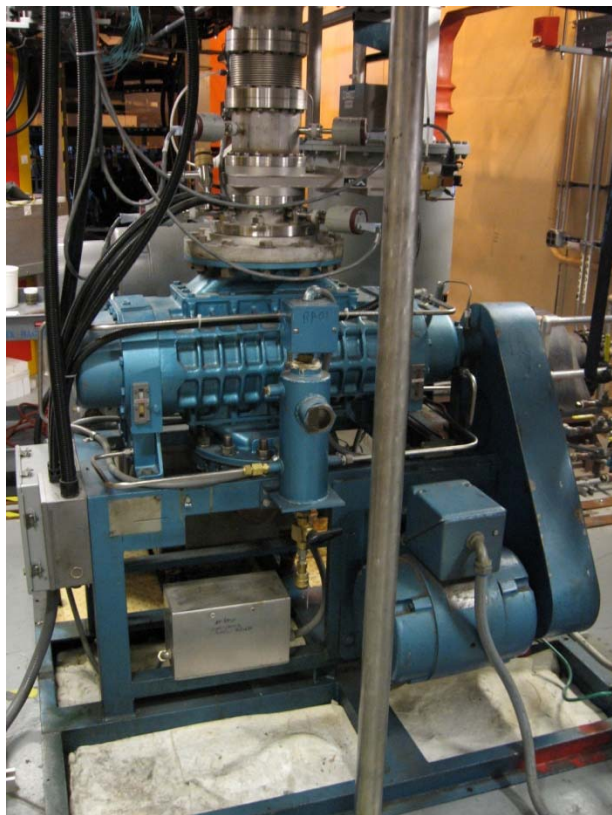


SF6 System

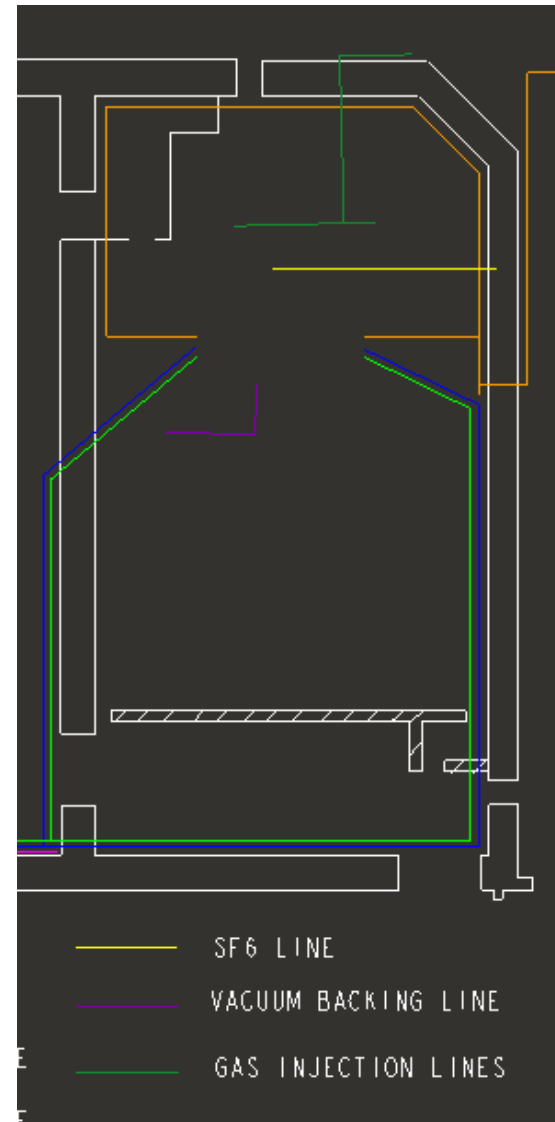


- N2 LINES
- He SUPPLY LINE
- He COLD RETURN LINE
- He WARM RETURN LINE
- SF6 LINE
- VACUUM BACKING LINE
- GAS INJECTION LINES

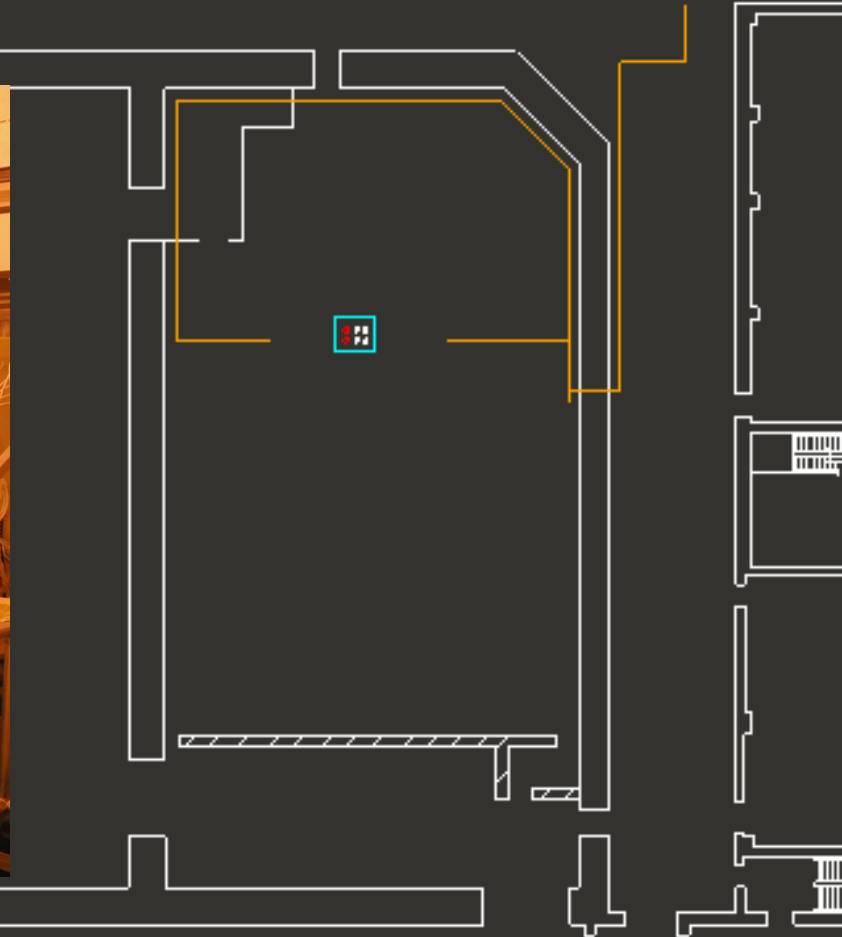
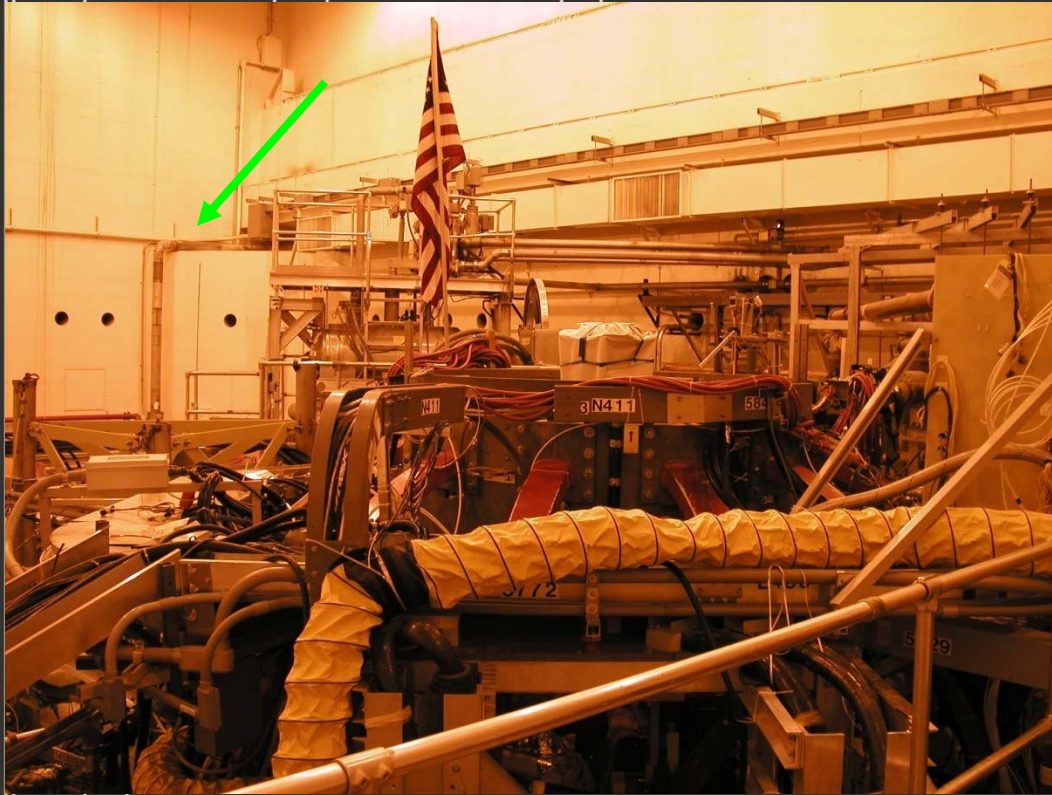
Vacuum Backing System



Gas Injection System



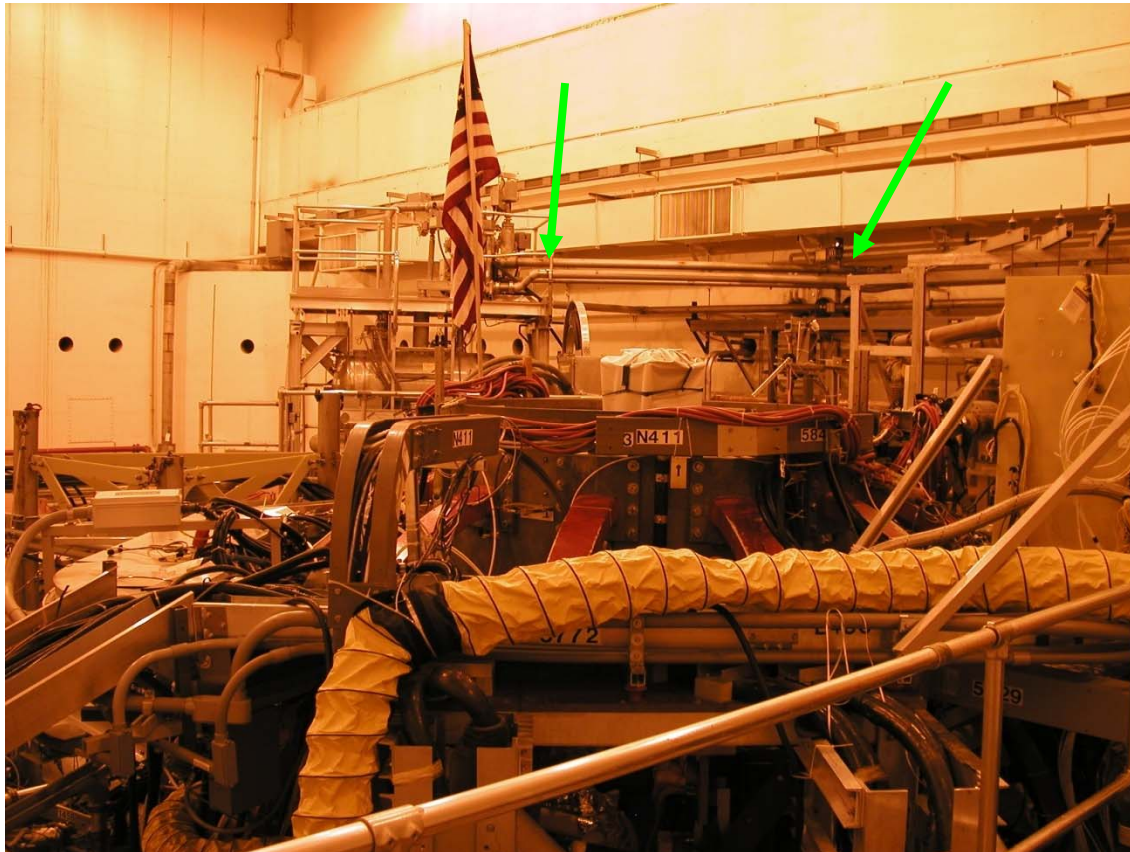
Liquid Nitrogen NSTX Test Cell



— N2 LINES
| SUPPLY
| RETURN

Cryogenic Lines

- Paths chosen to minimize pipe runs and heat loads
- Calculations show we can use current refrigeration system for two beam lines.



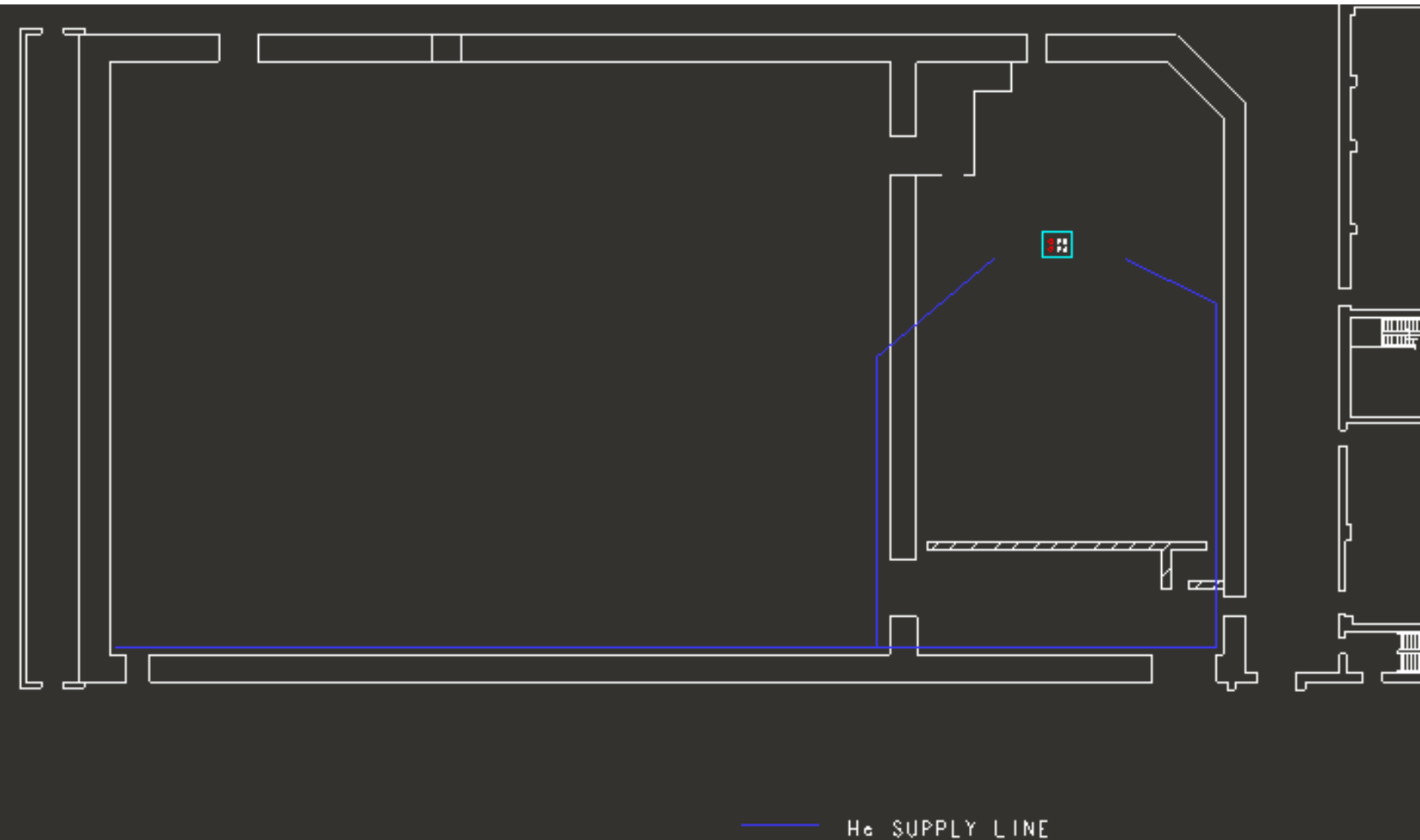
Cryogenic System Heat Loads

• Existing Supply	207W
• Return Estimate	250W
• Transfer Lines Supply	21W
• Transfer Lines Return	25W
• Valves X4	16W
• Bayonets X4	12W
• Total Heat Load	567W
• Refrigerator Capacity	700W
• Spare Refrigeration	133W

Liquid Helium Penetrations



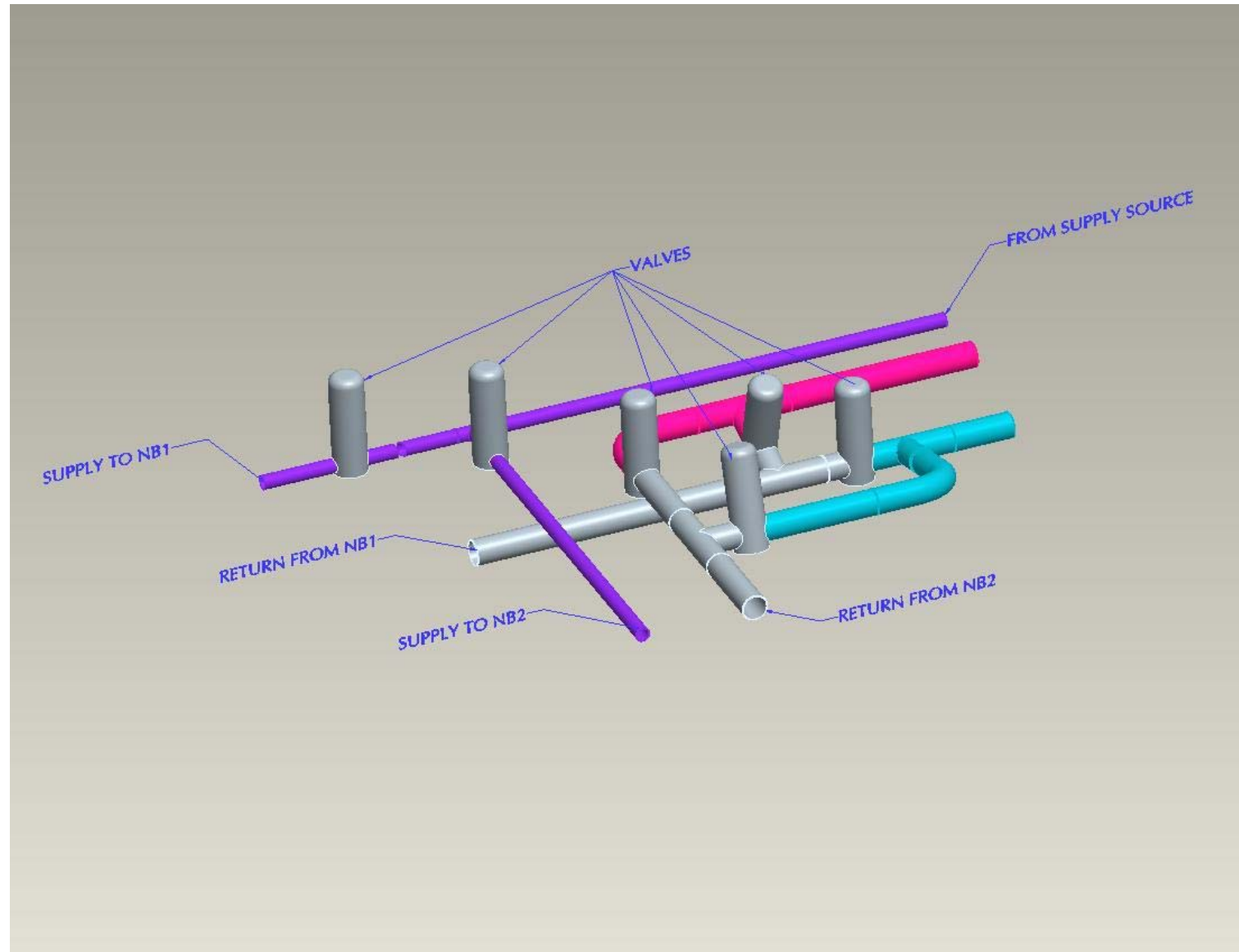
Liquid Helium TFTR & NSTX Test Cell



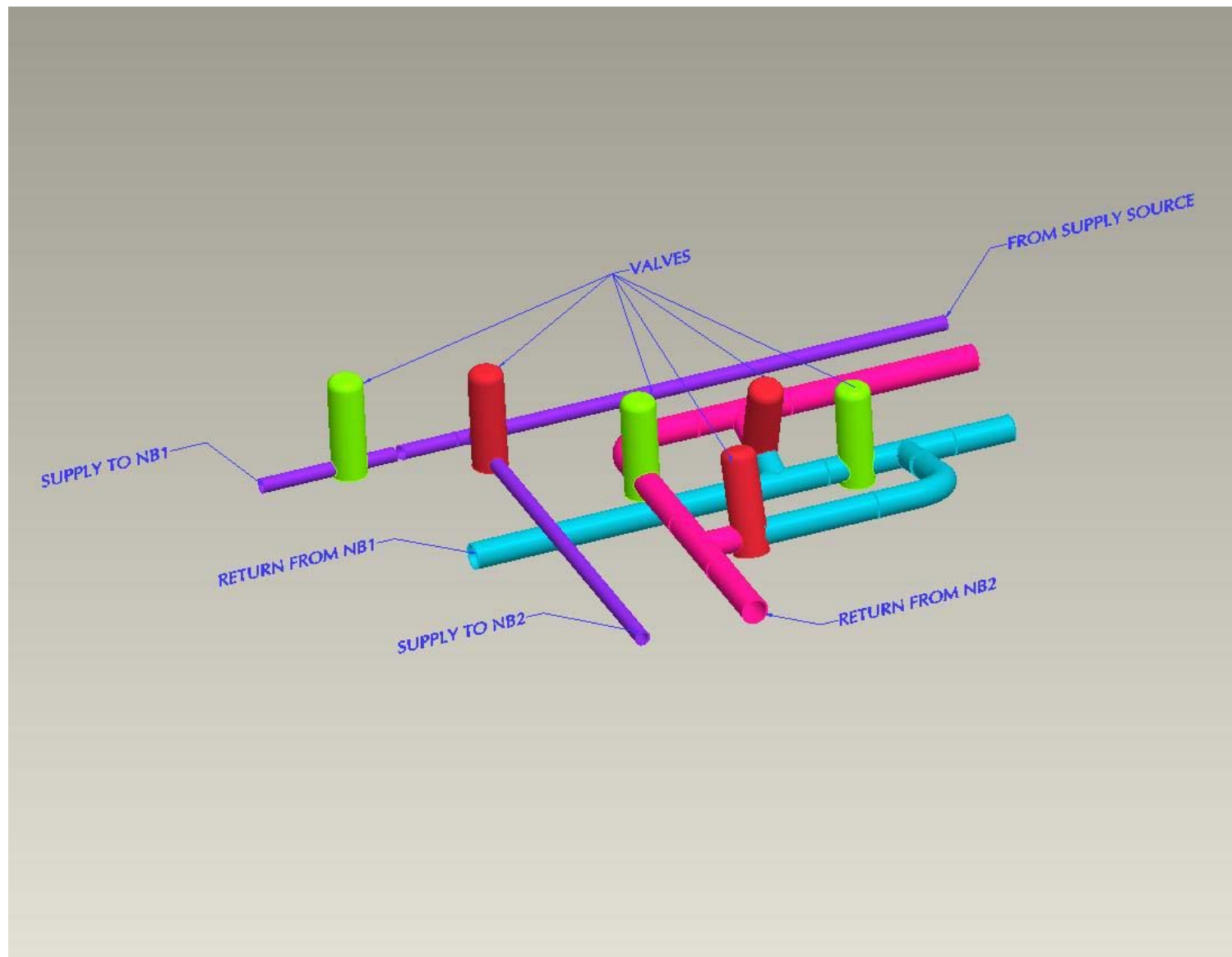
Liquid Helium Valves



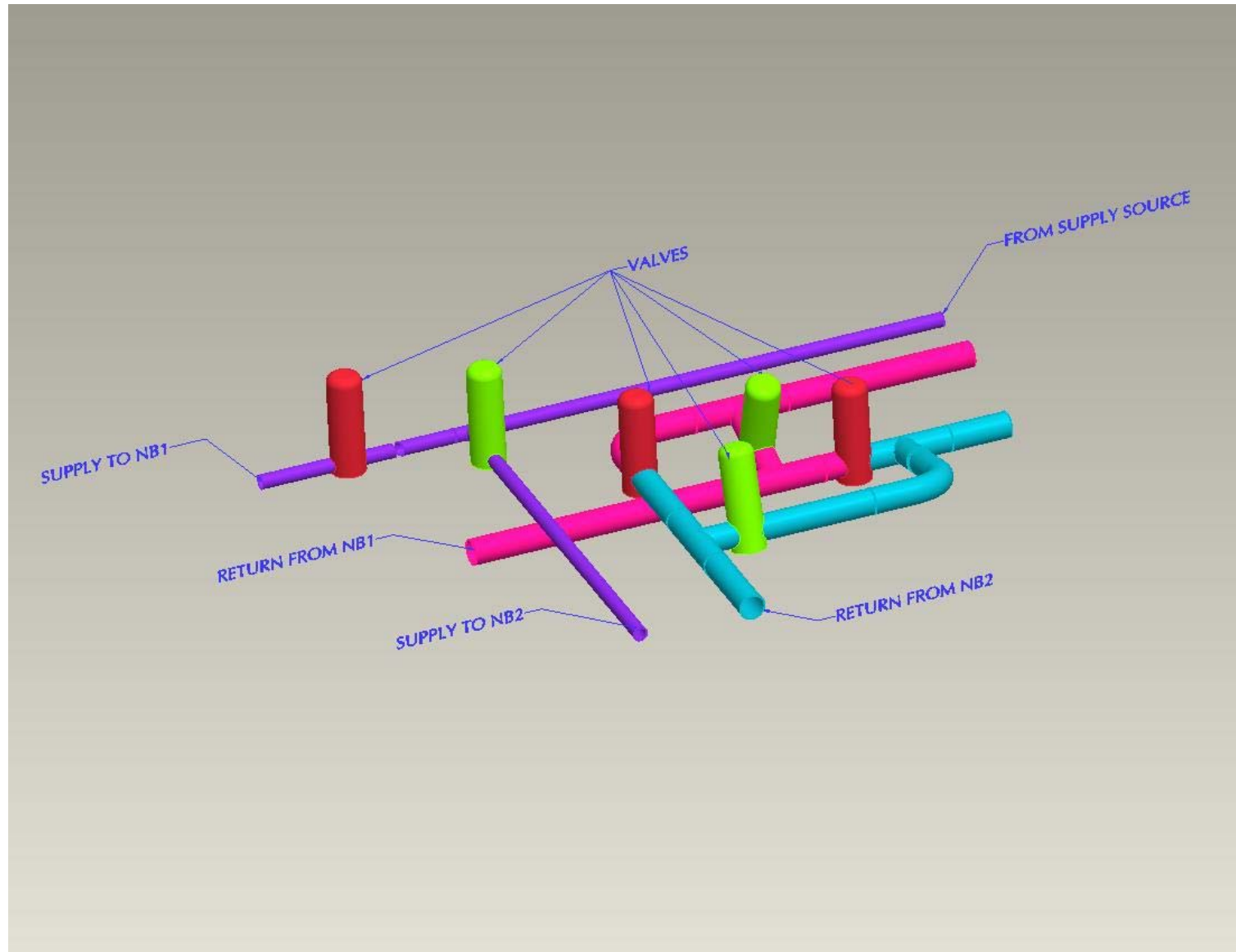
Cryogenic Valves



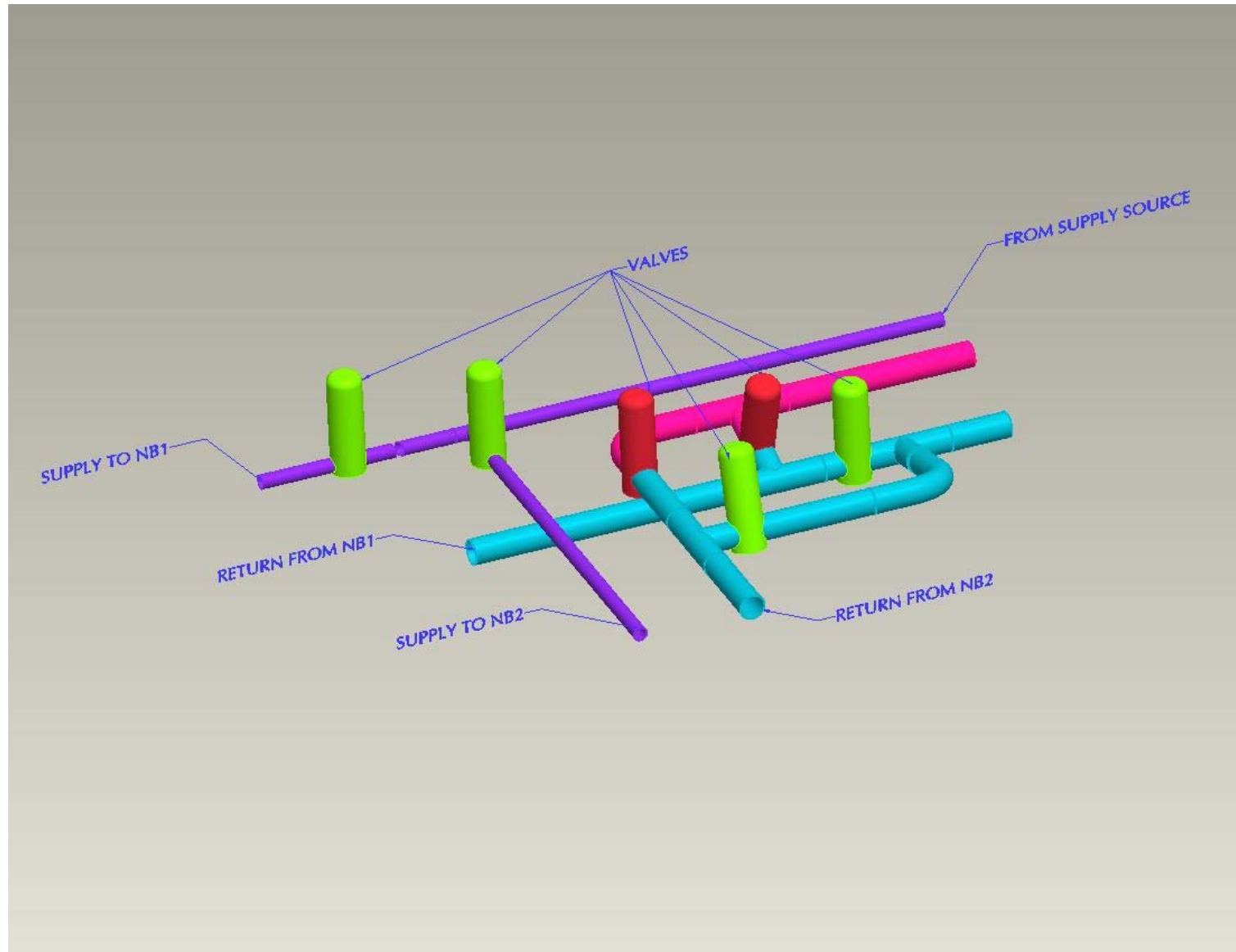
NBI 1 Cool Down



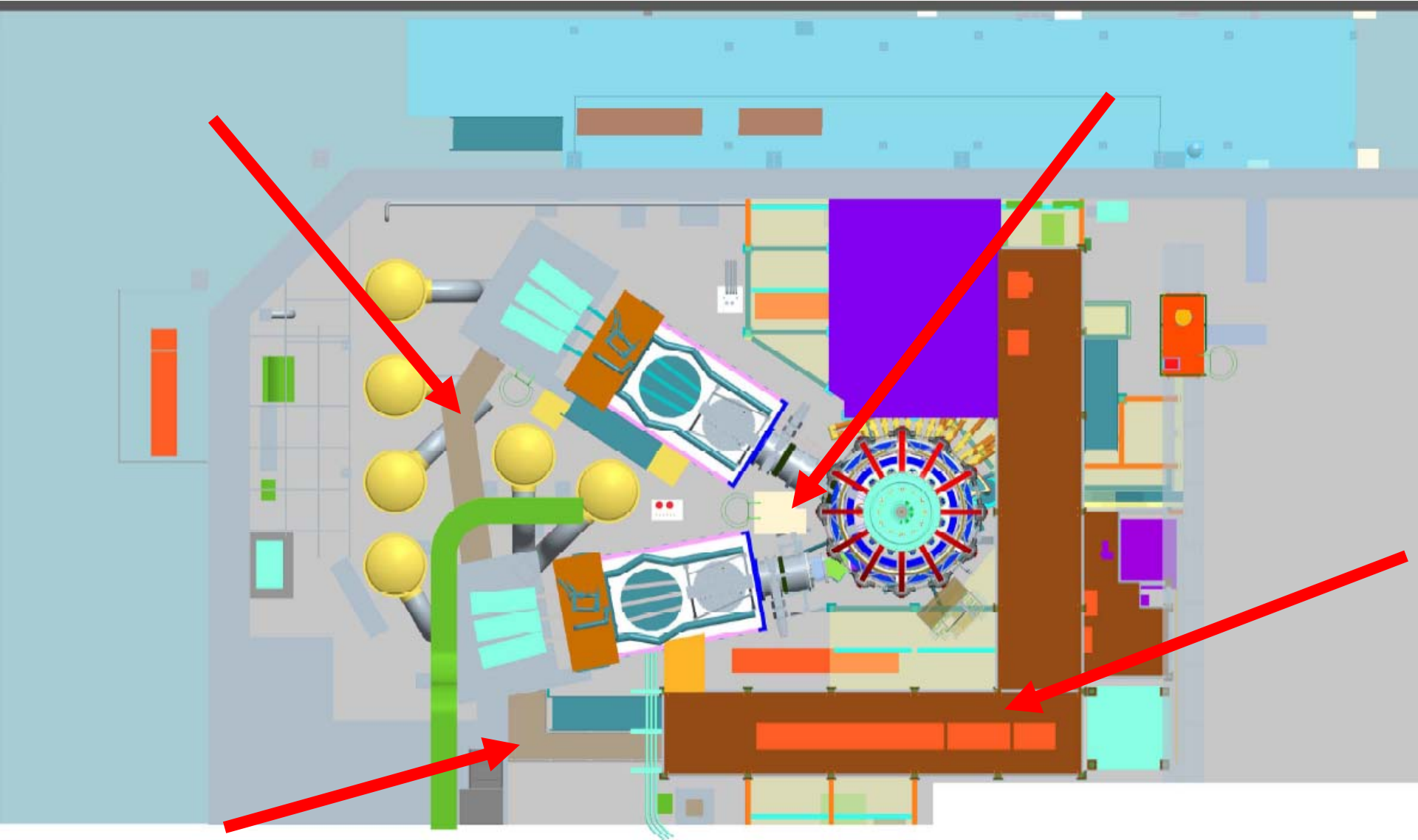
NBI 2 Cool Down



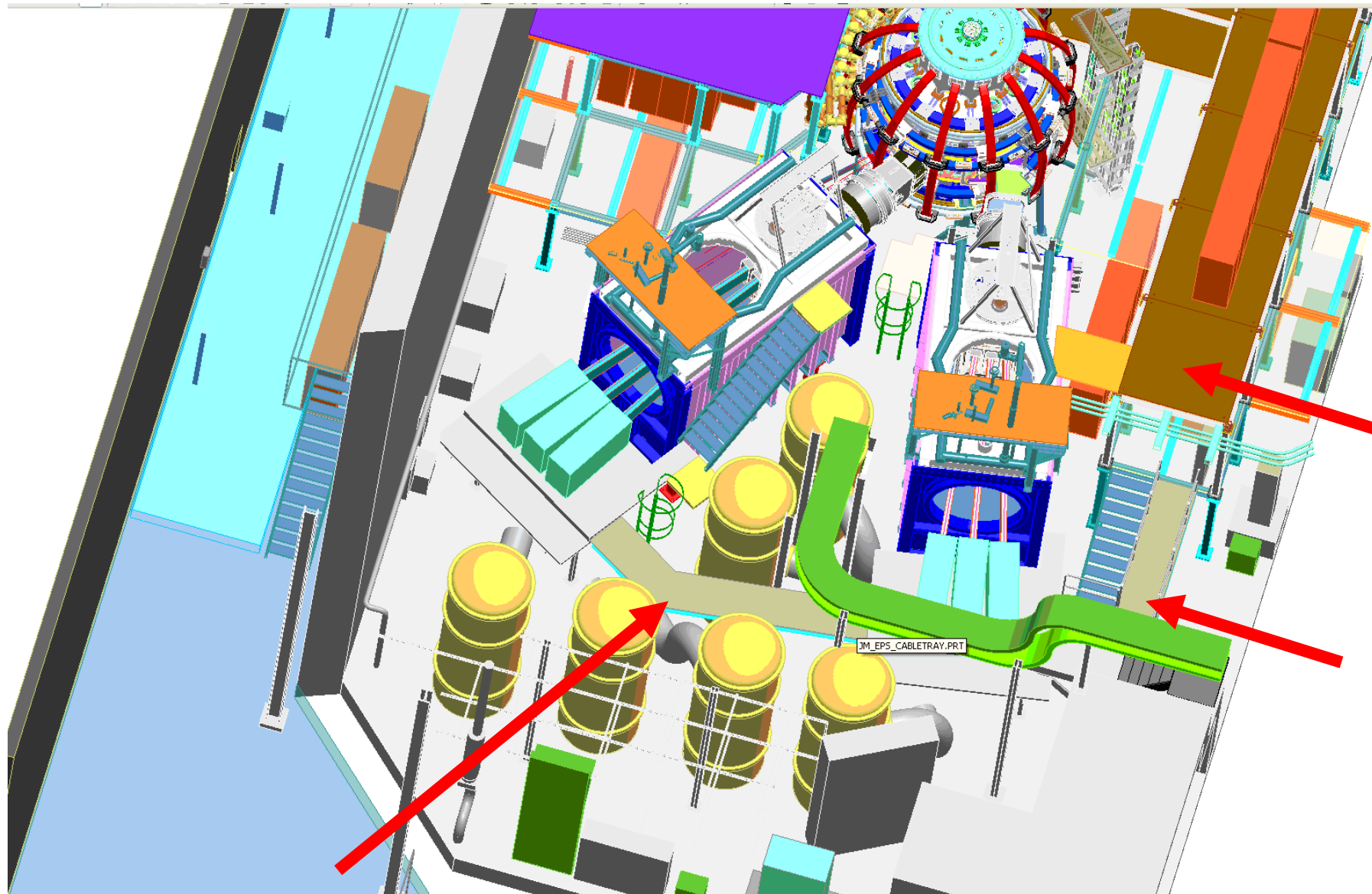
NBI 1 & 2 Operations



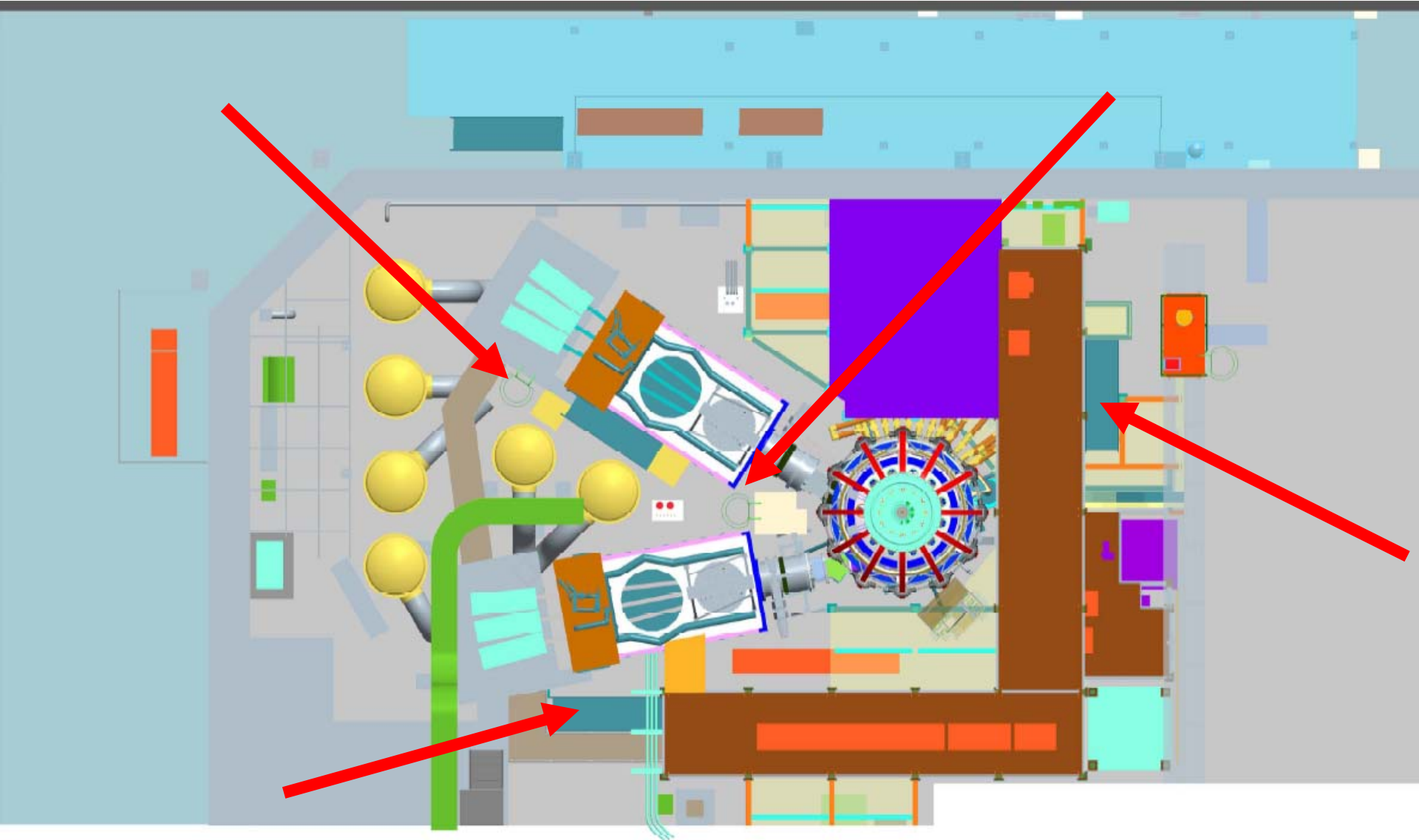
New Platform



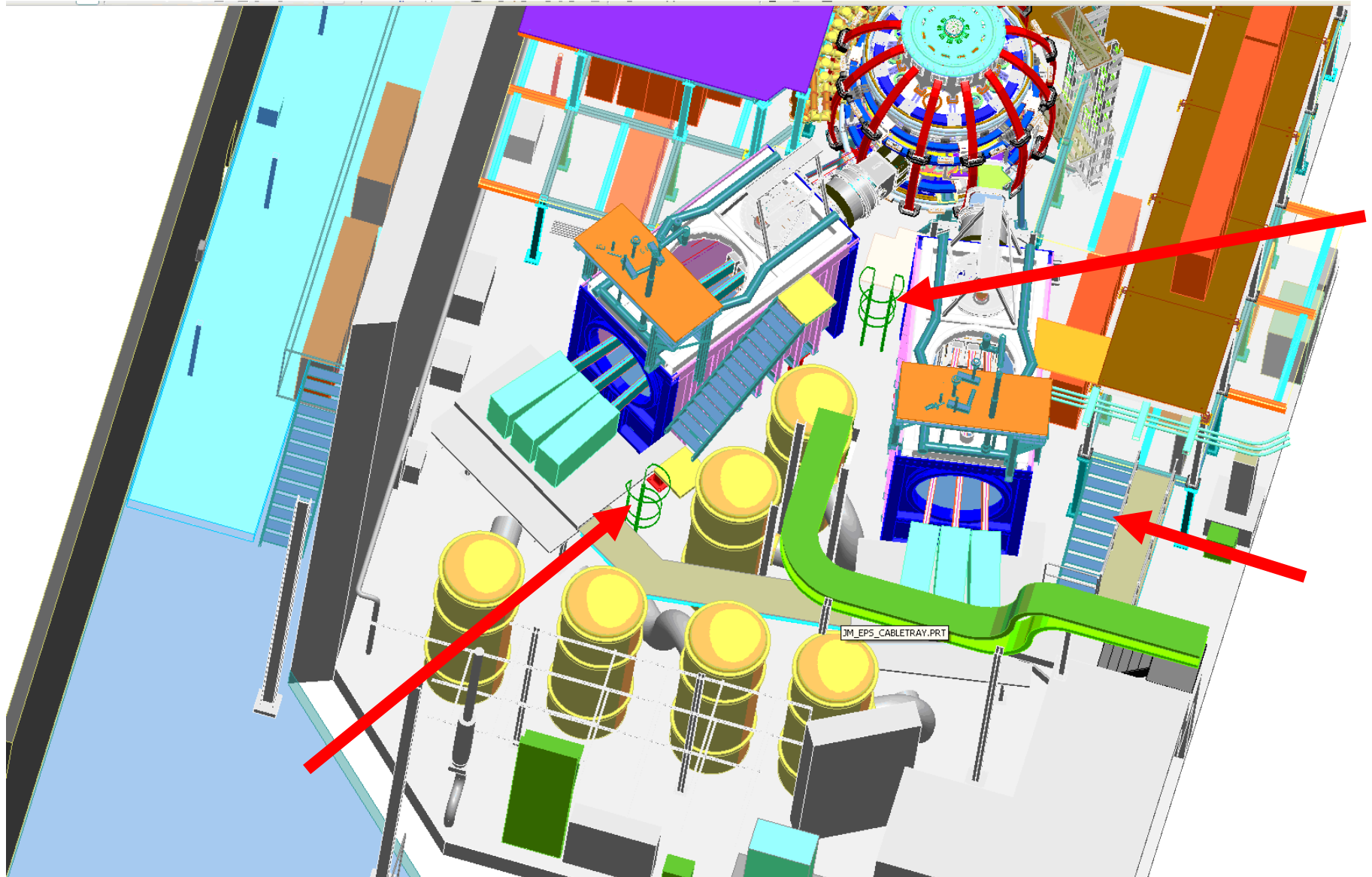
New Platform



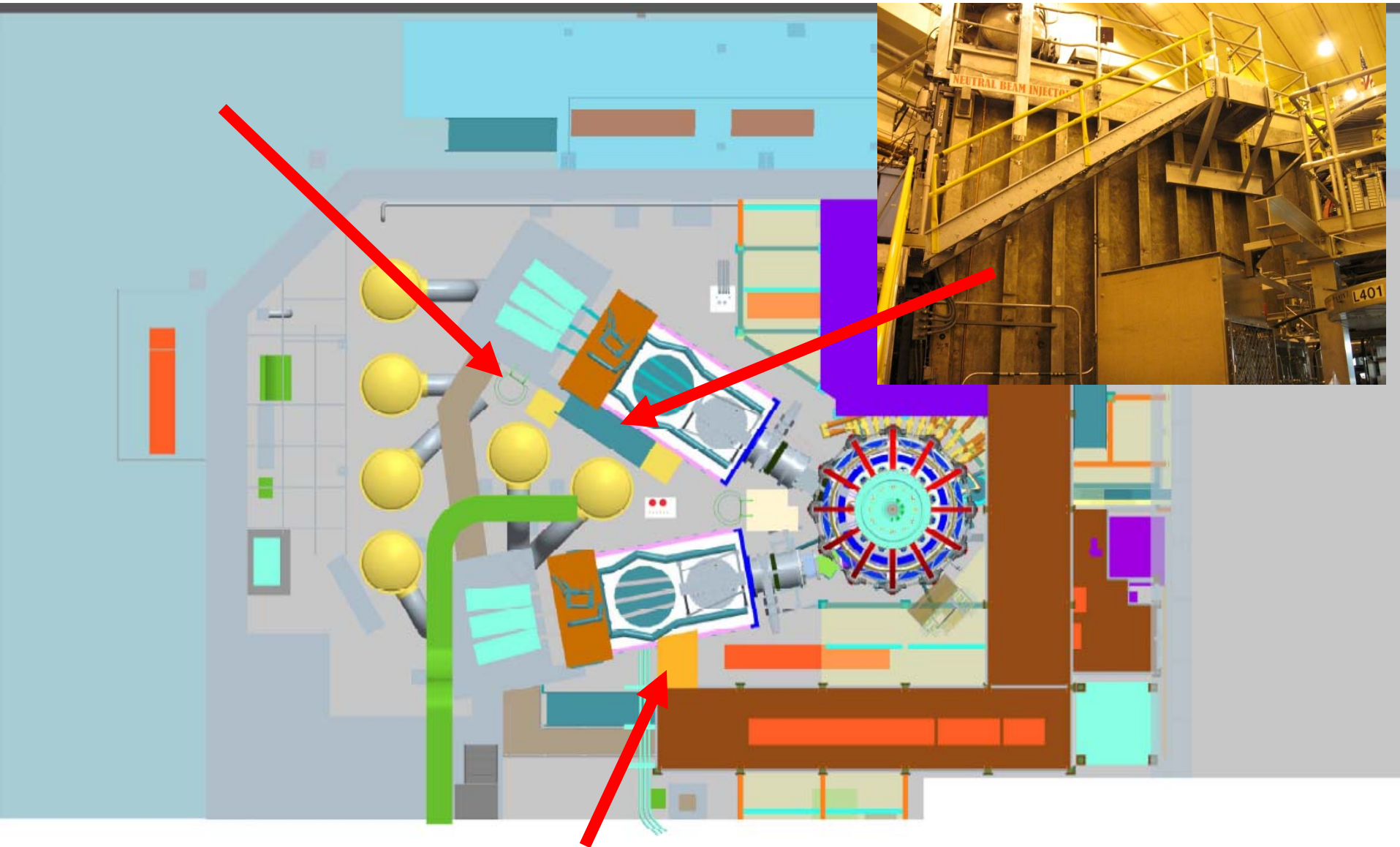
New Platform Stairs and Ladders



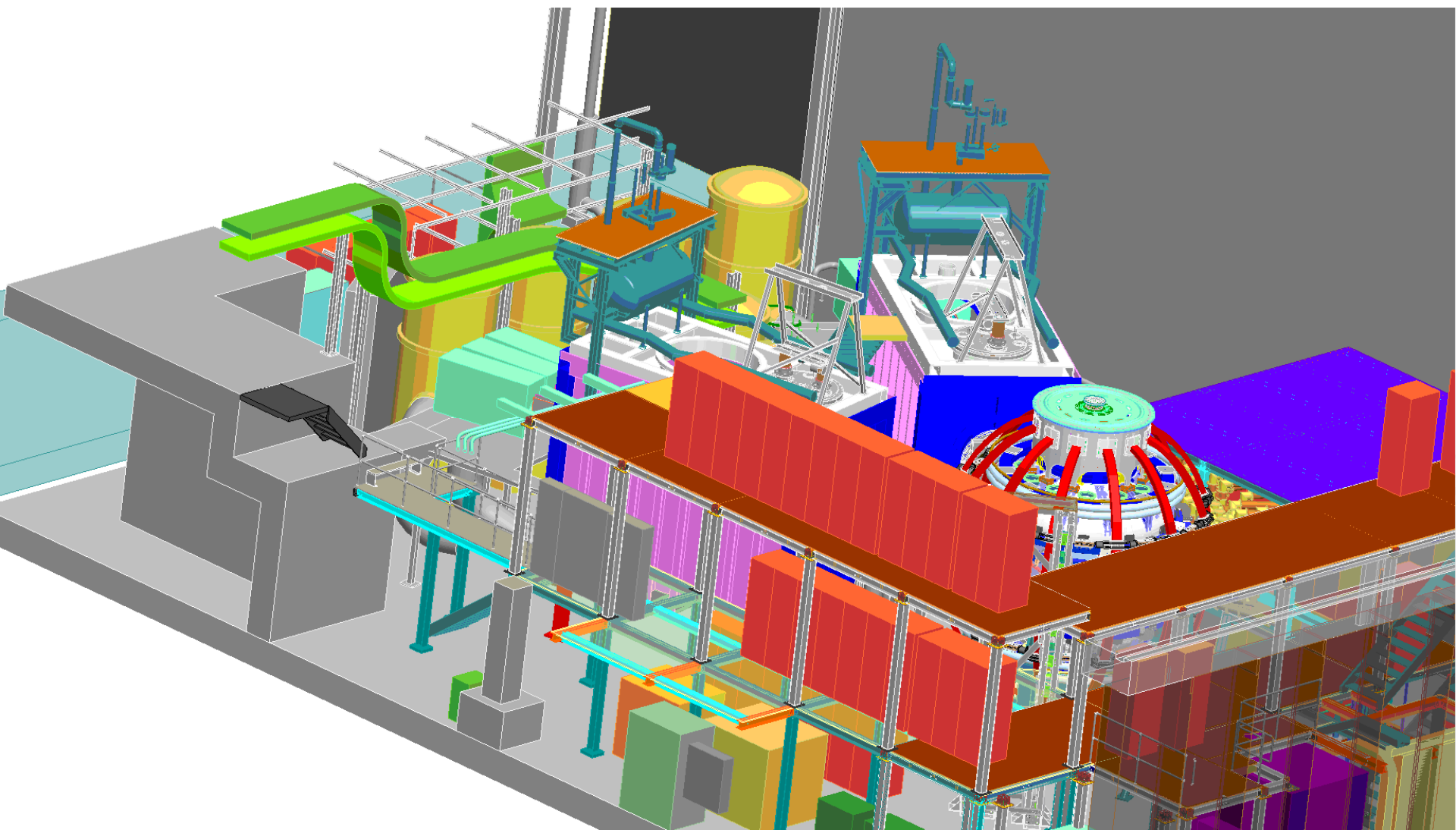
New Platform Stairs and Ladders



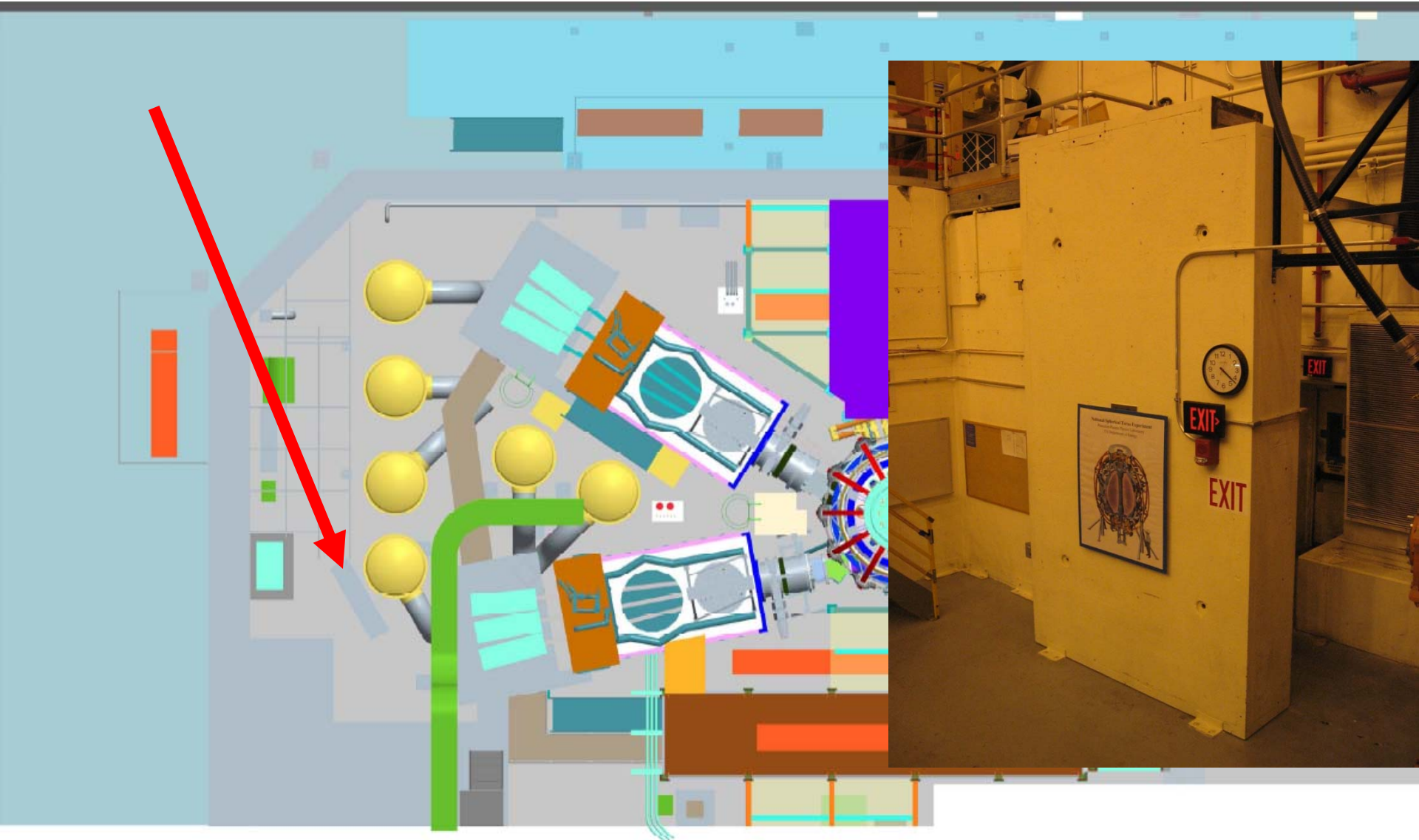
New Platform Beam Access



New Platform



Labyrinth



Summary

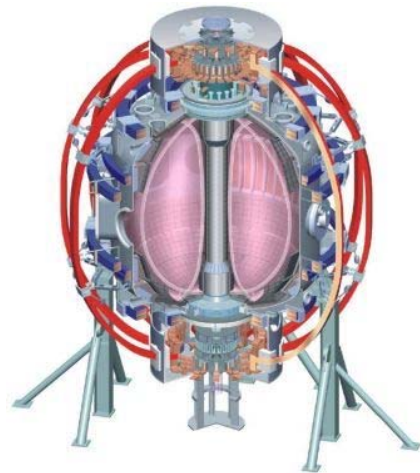
- All NBI components identified and movement paths determined.
- All services accounted for, optimized, and routings approved.
- Platform requirements identified and supported by design.

Questions?

NBI 2 Duct and Vessel Interface

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June, 2011**



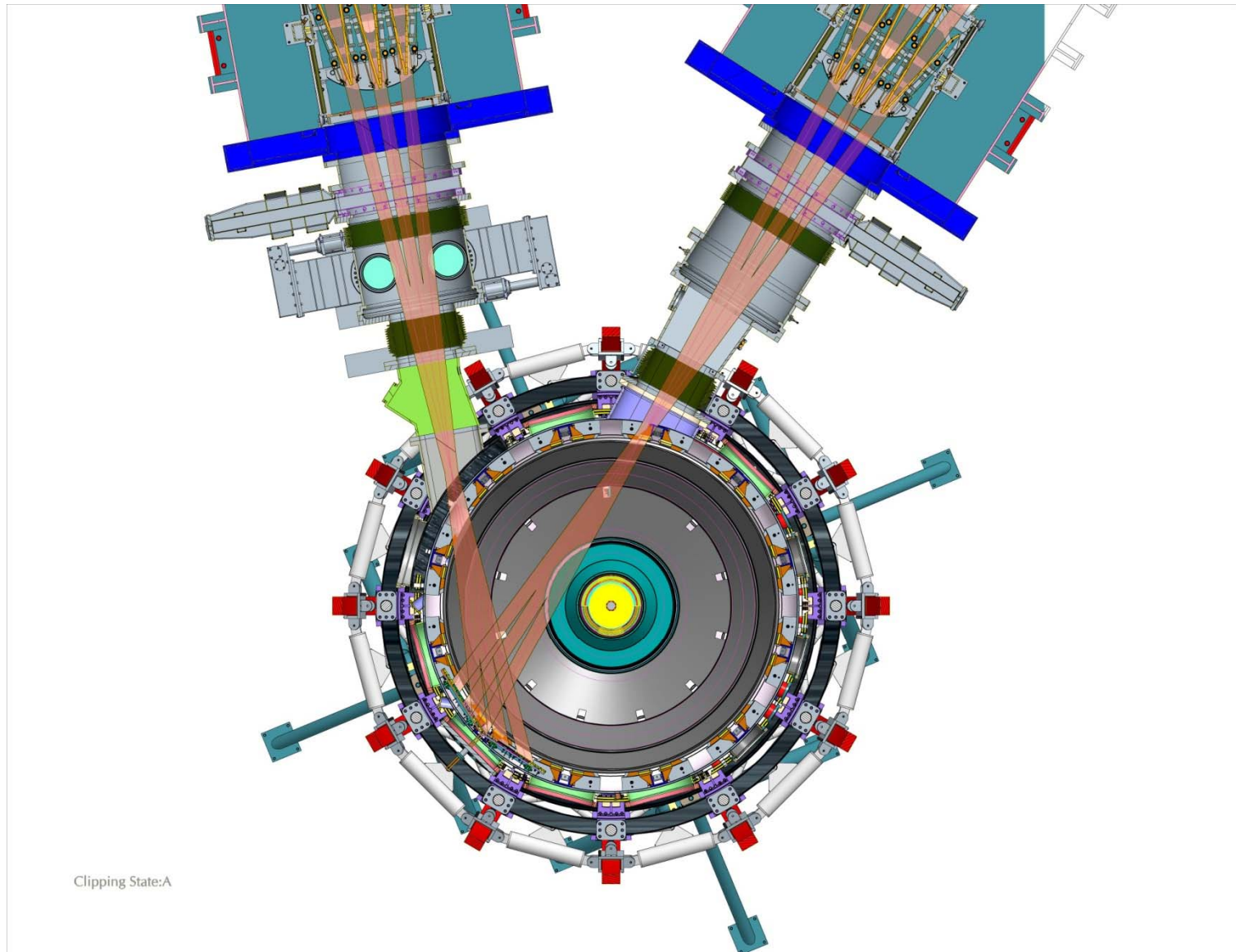
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Duct and Vessel Interface Scope

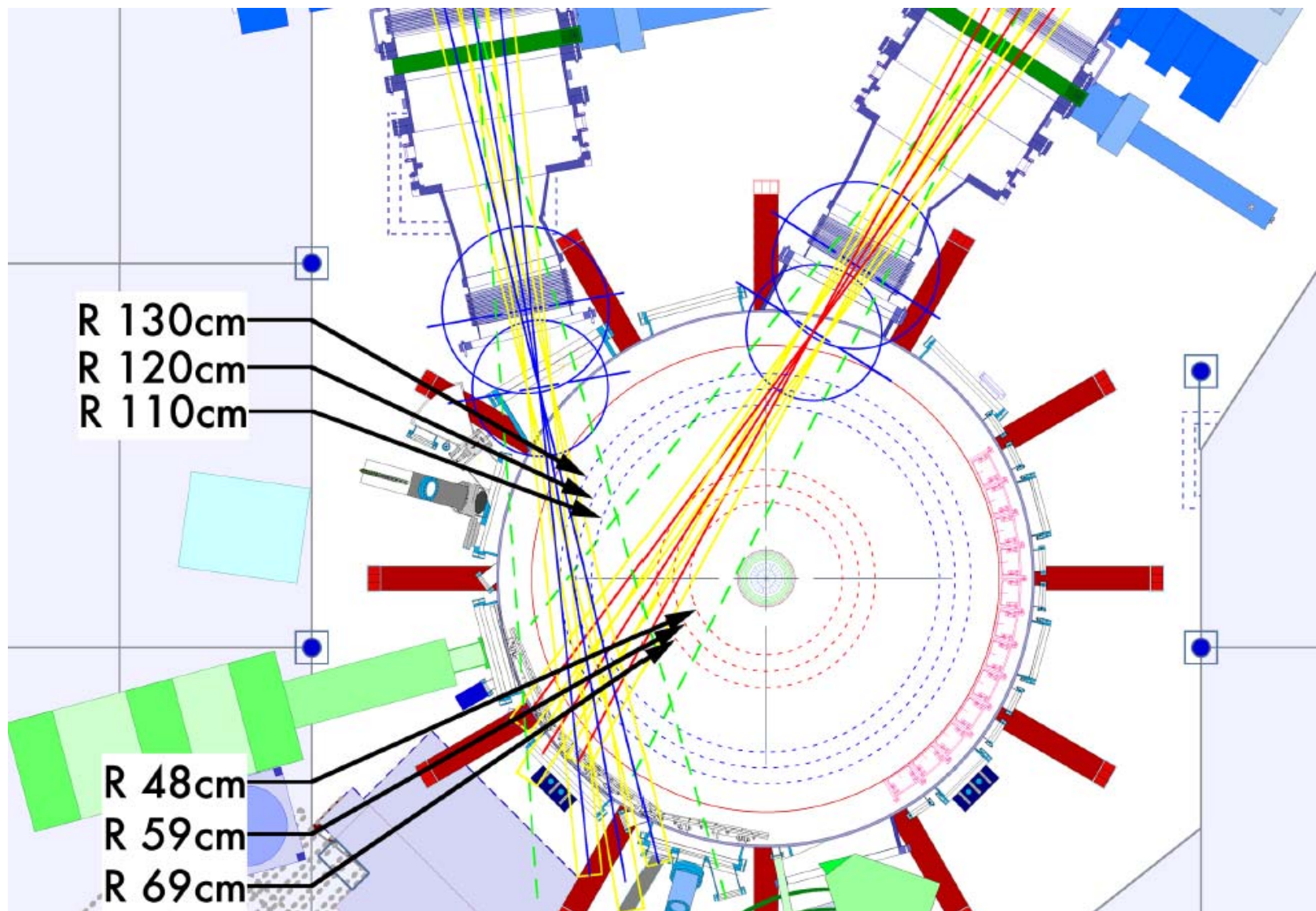
- Provide duct to connect NBI2 to NSTX
- Accommodate vessel pumping
- Modify NSTX vessel to accept 2nd NBI's alignment

NSTX with 2 NBI's

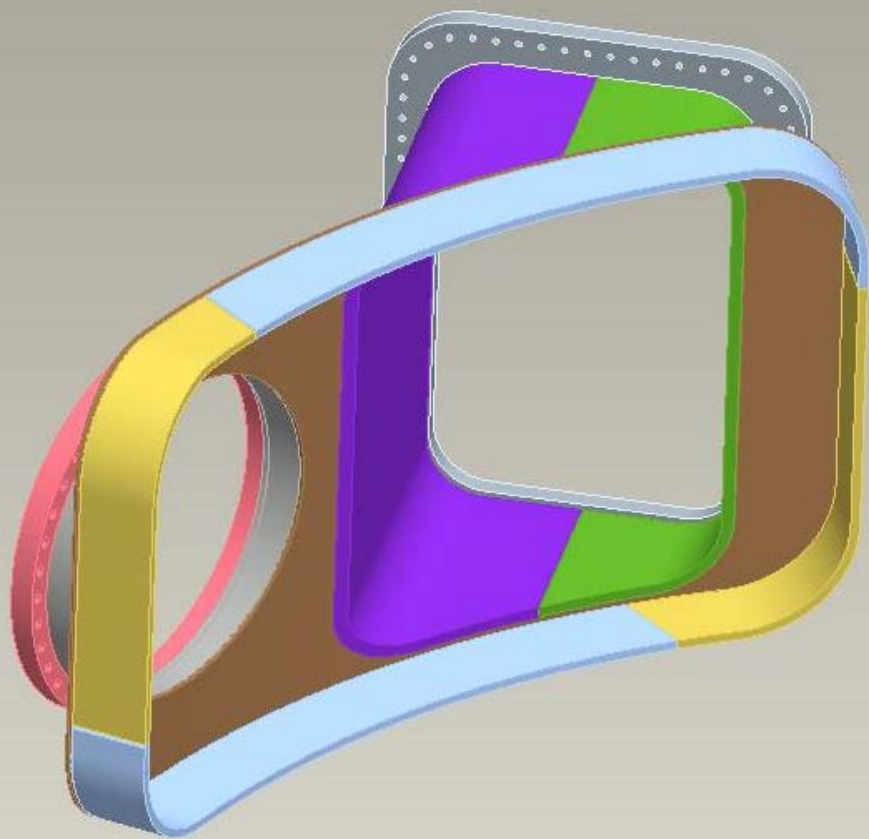


Clipping State:A

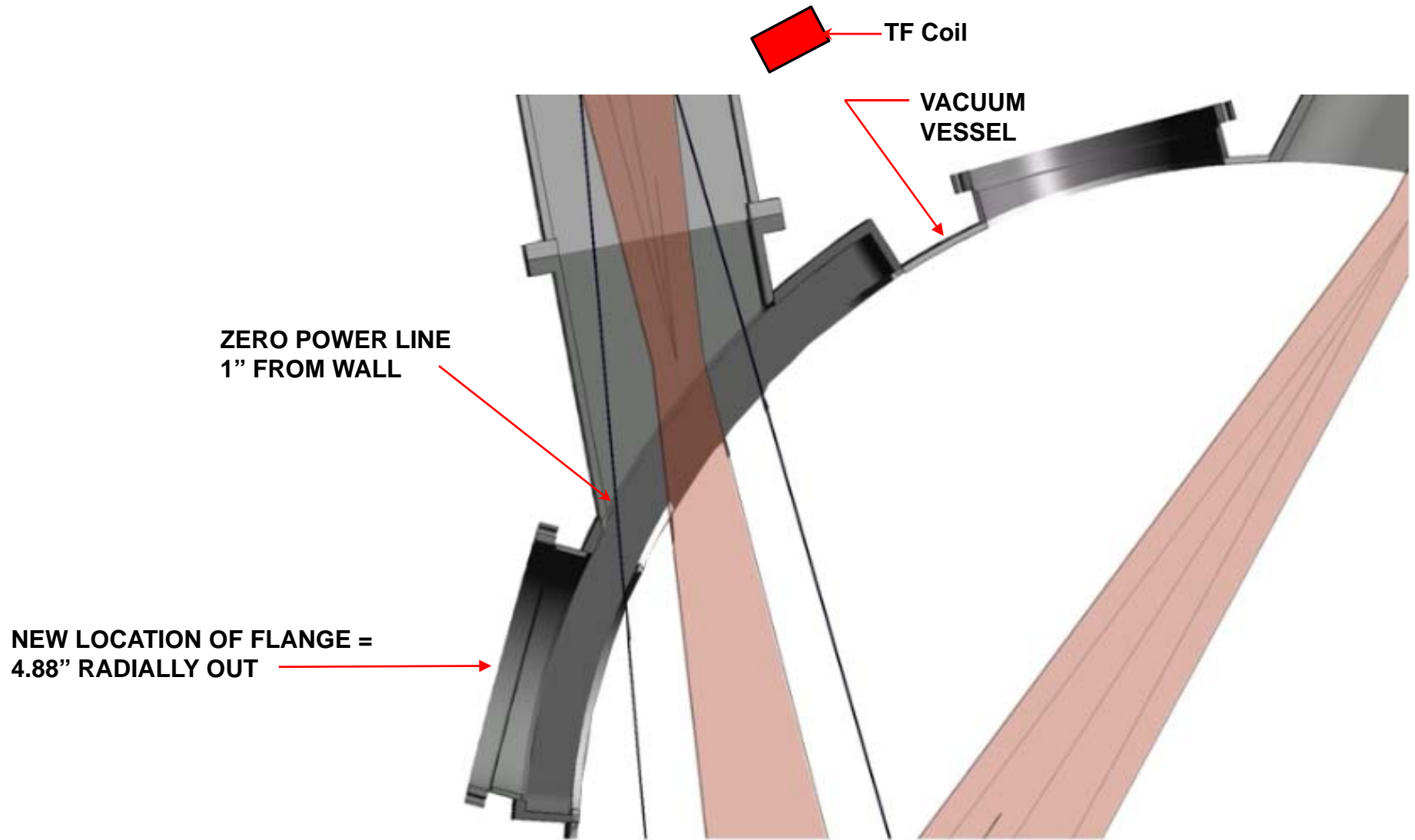
NBI Tangency Radii



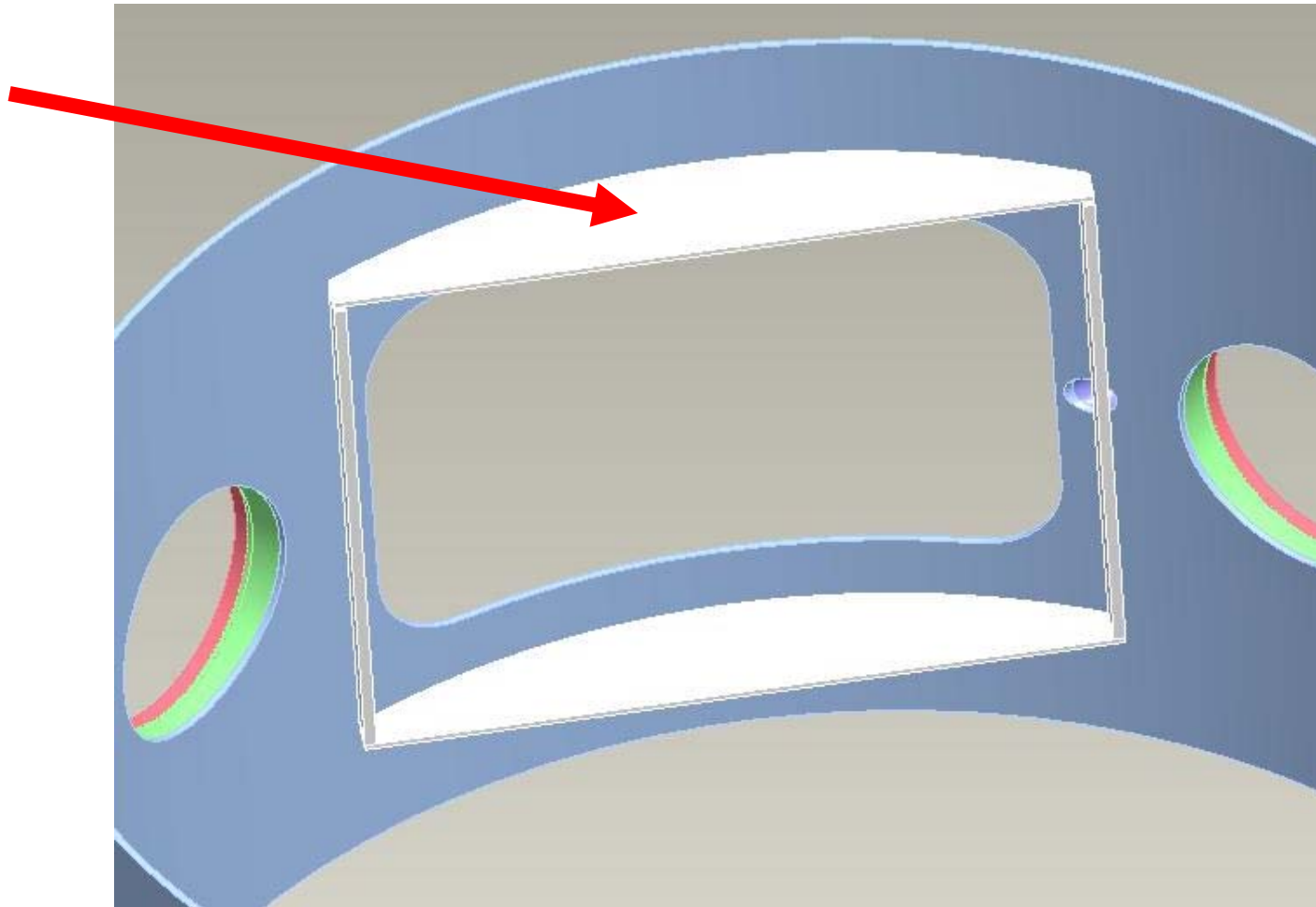
Vessel Cap



NSTX Vessel Modification: Motivation

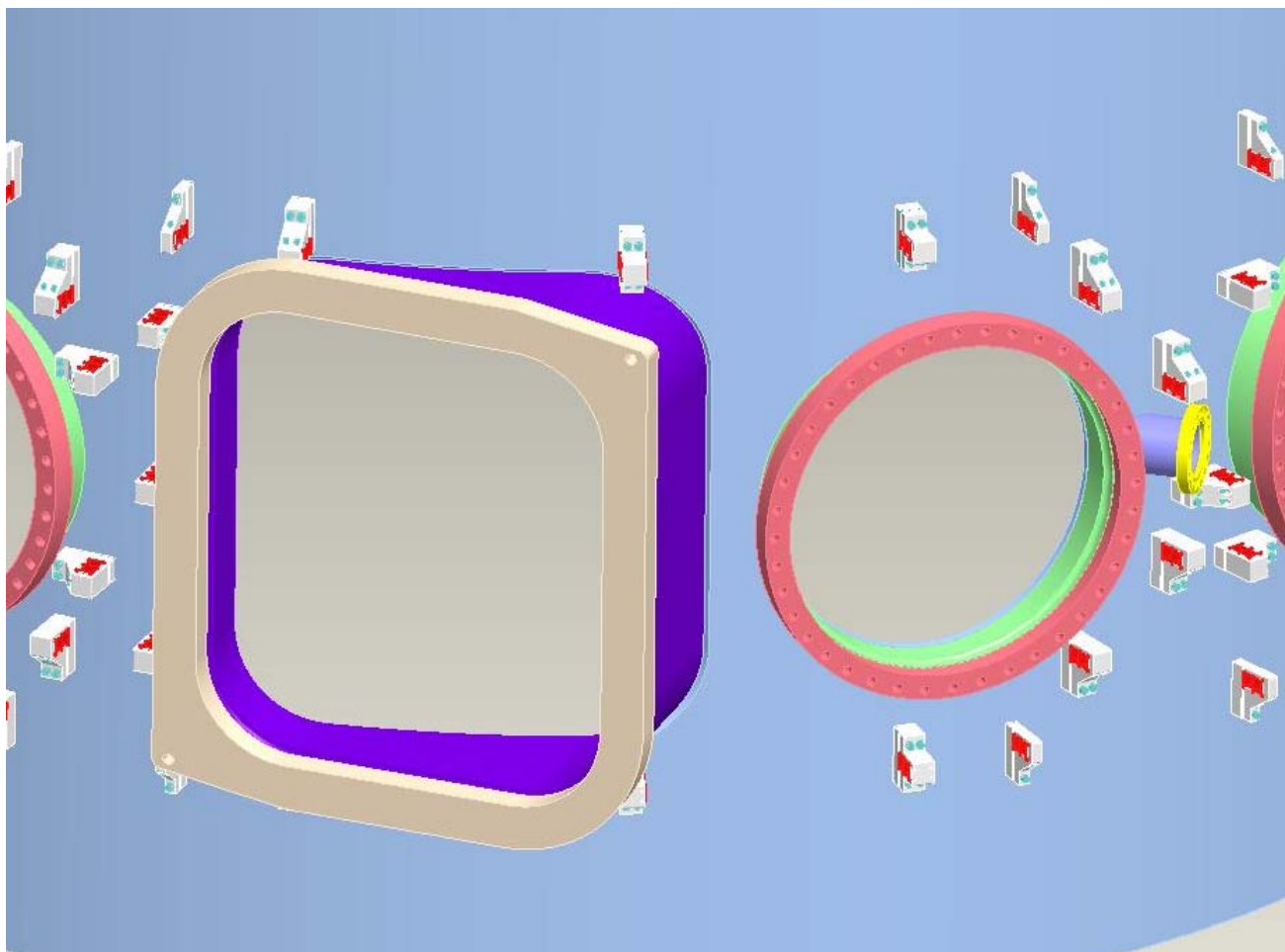


Cap Installation Plan



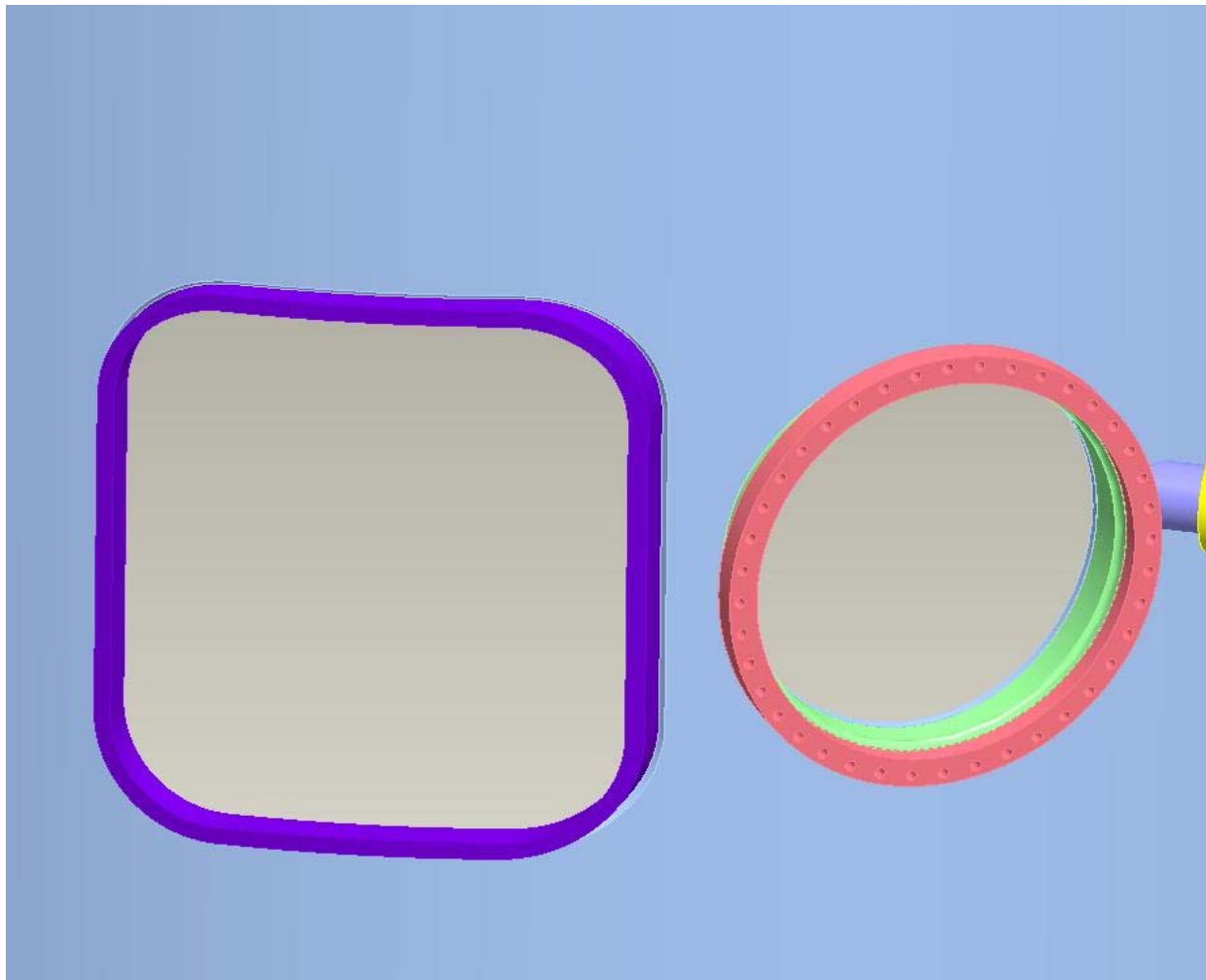
- *Temporary in vessel bracing*
- *Bracing remains in place until installation of cap is finished*

Cap Installation Plan



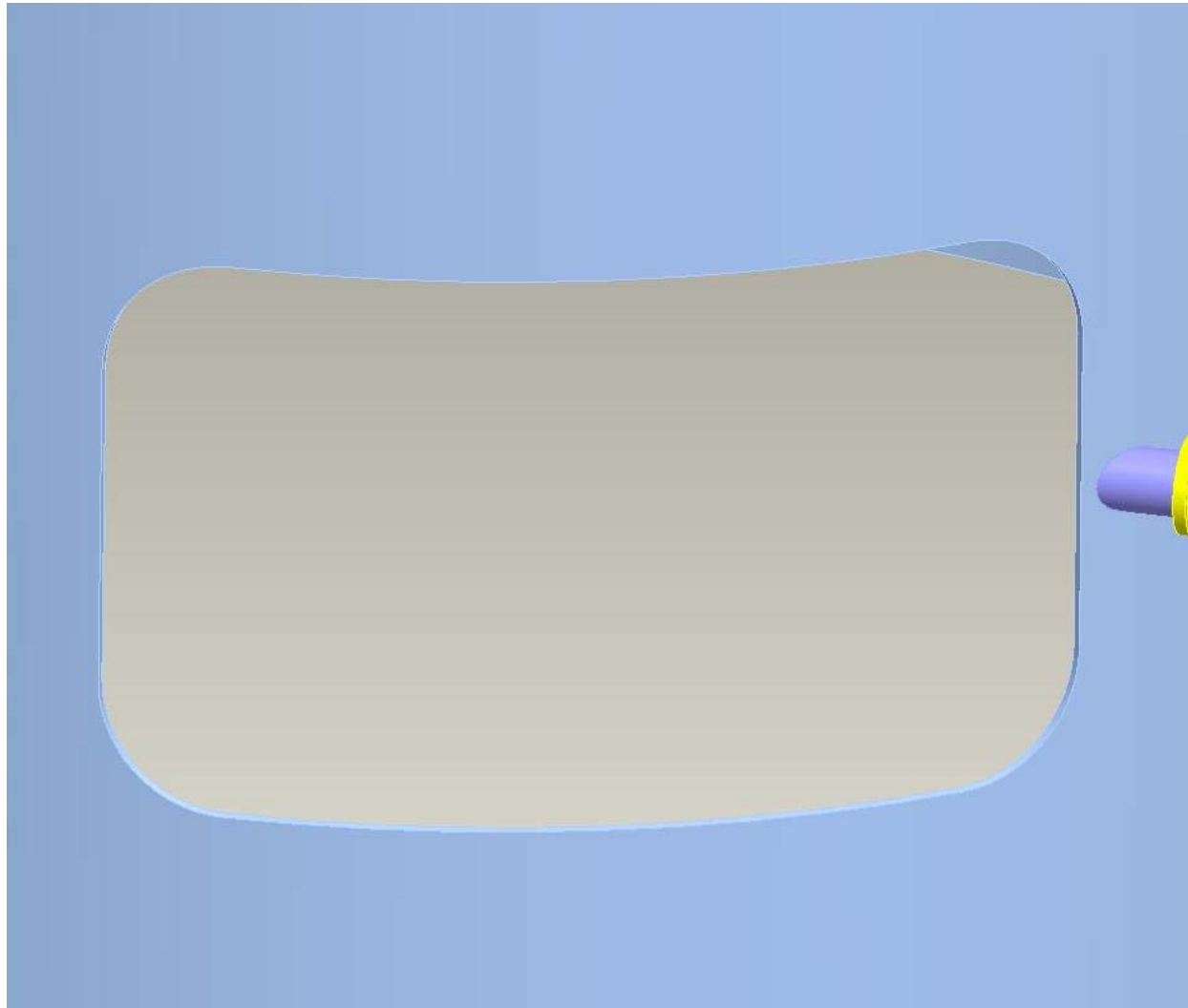
- *Bay K and J diagnostics removed,*
- *TF coil between J and K removed*
- *RWM coils/Vessel Bake out lines removed*

Cap Installation Plan



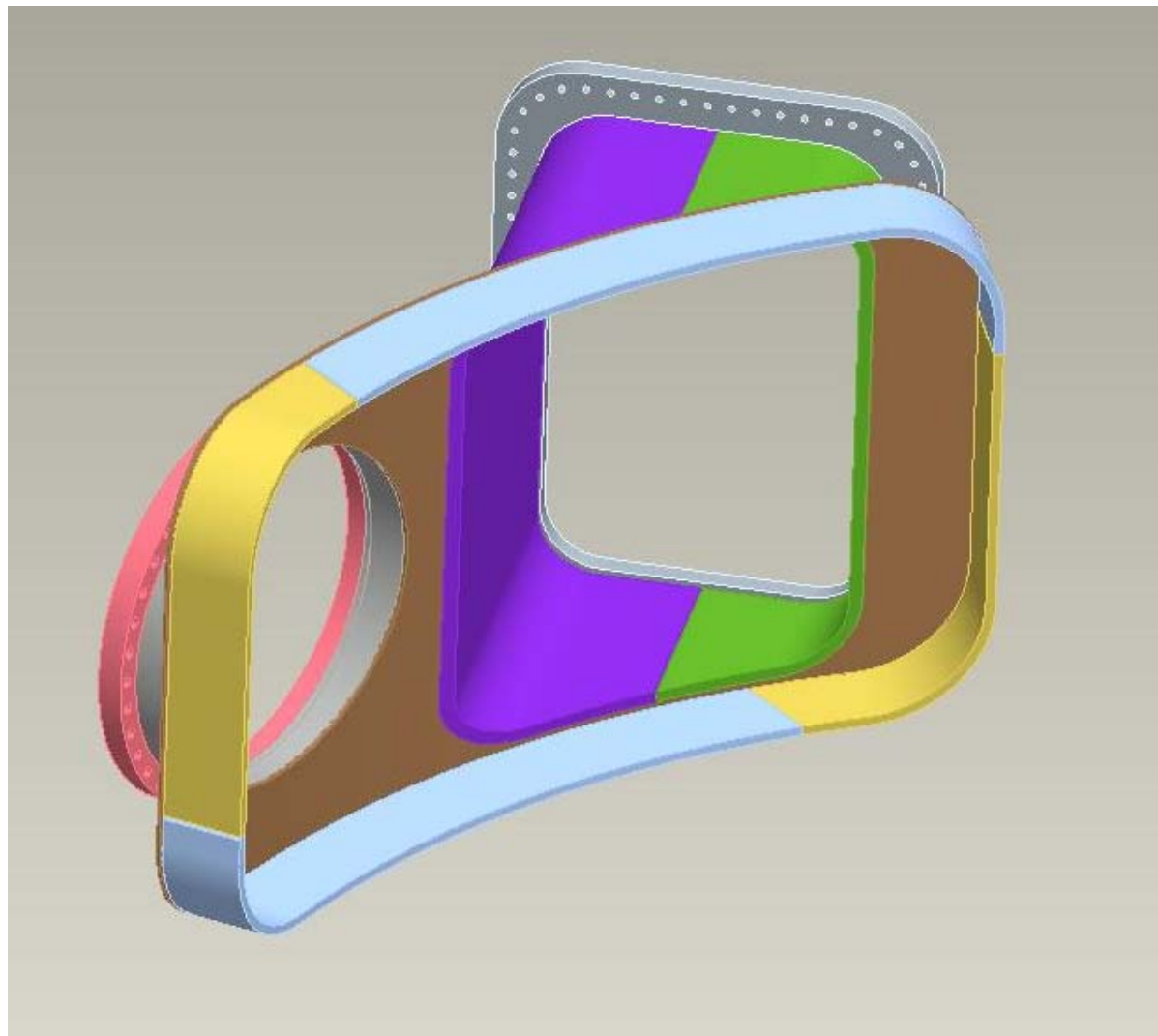
• *Bay K nozzle removed (plasma cut) as close to vessel as practical*

Cap Installation Plan



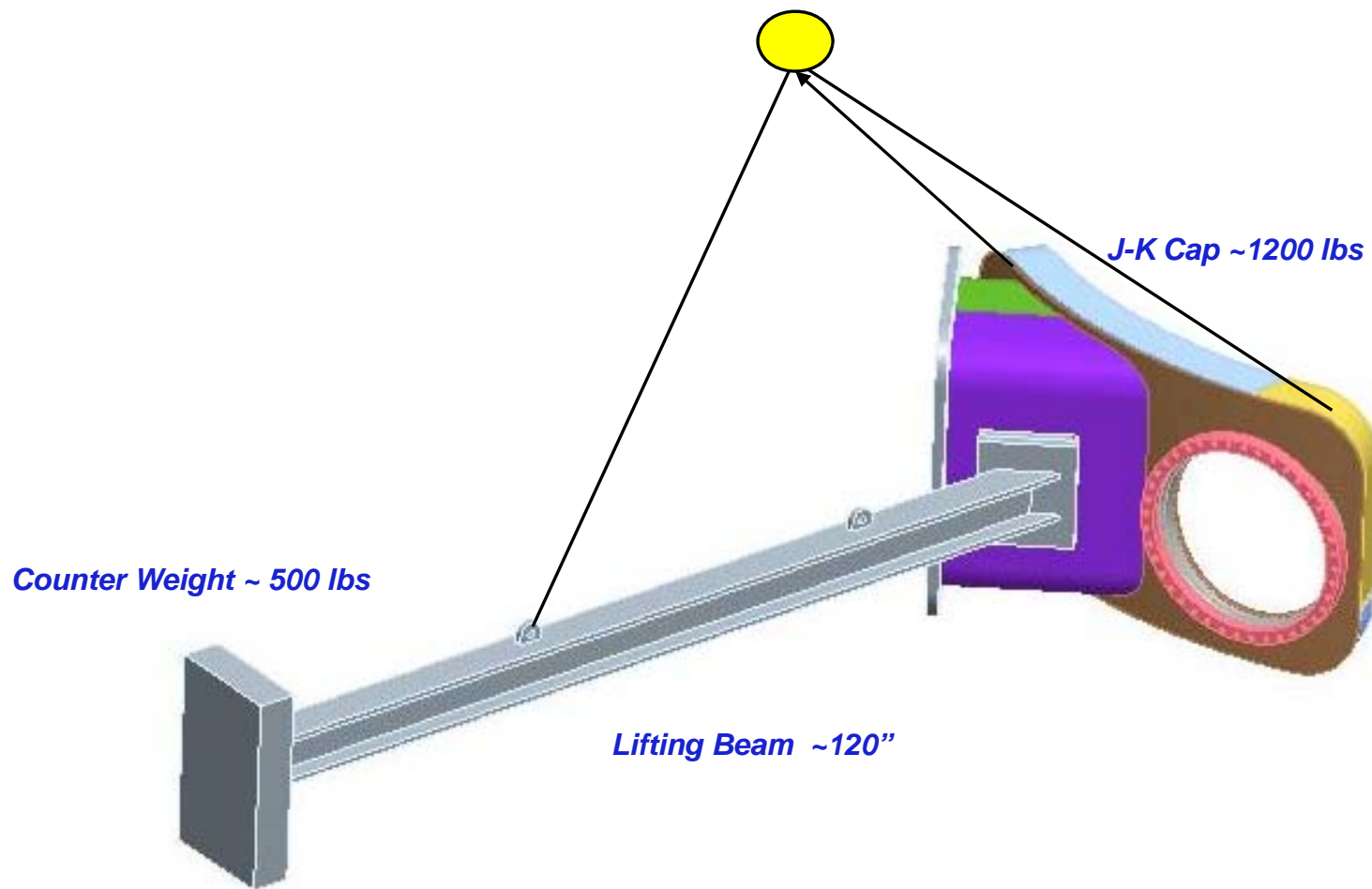
•Setup containment box and perform cut

Cap Installation Plan

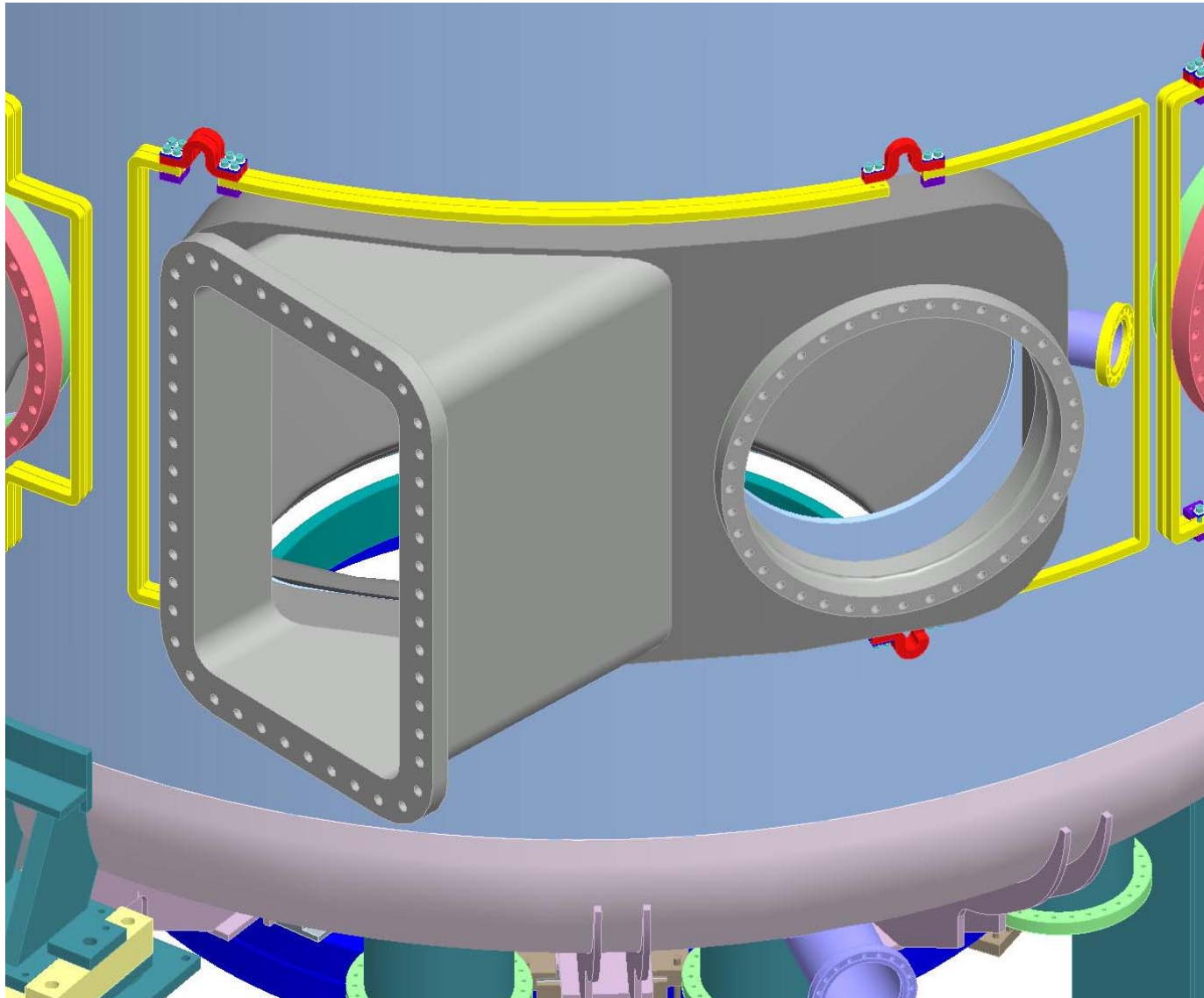


• *J/K Cap fabricated*

Final Cap Installation



Bay J/K Cap

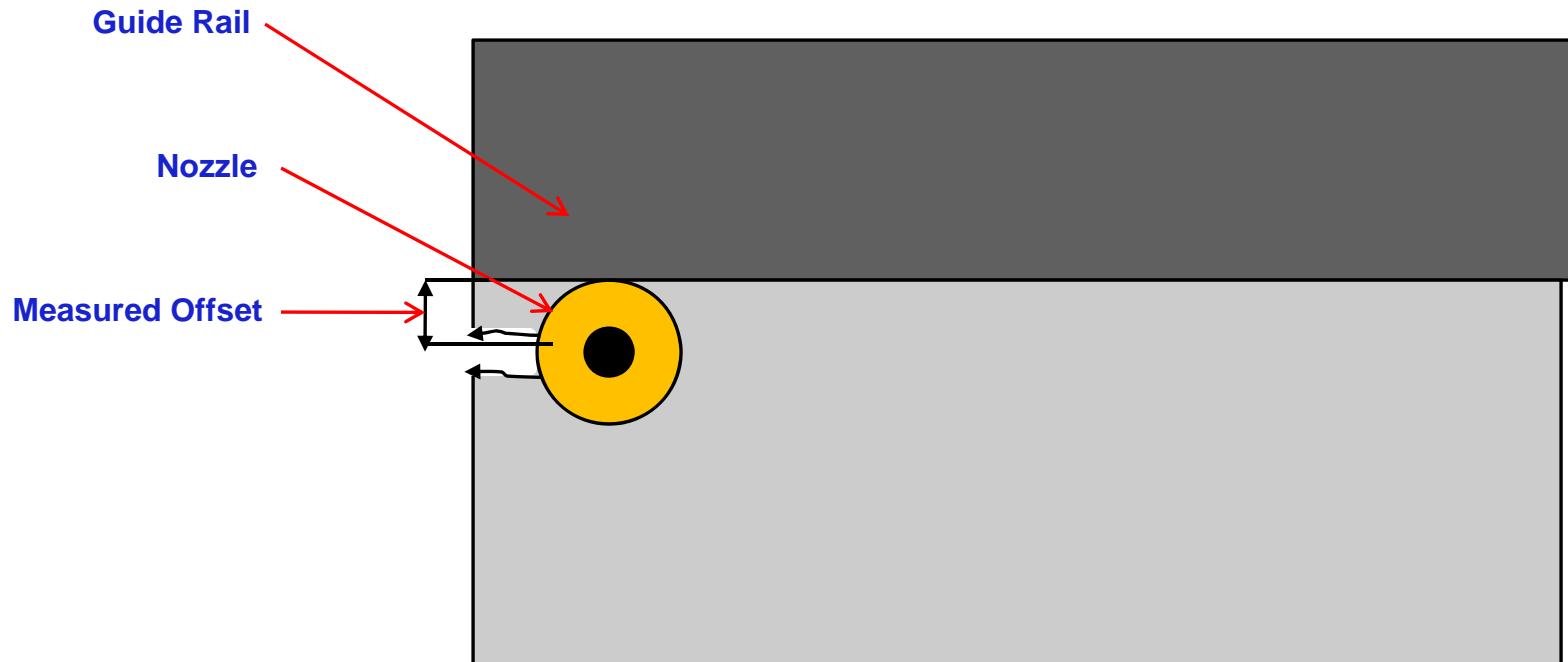


Vessel Cutting

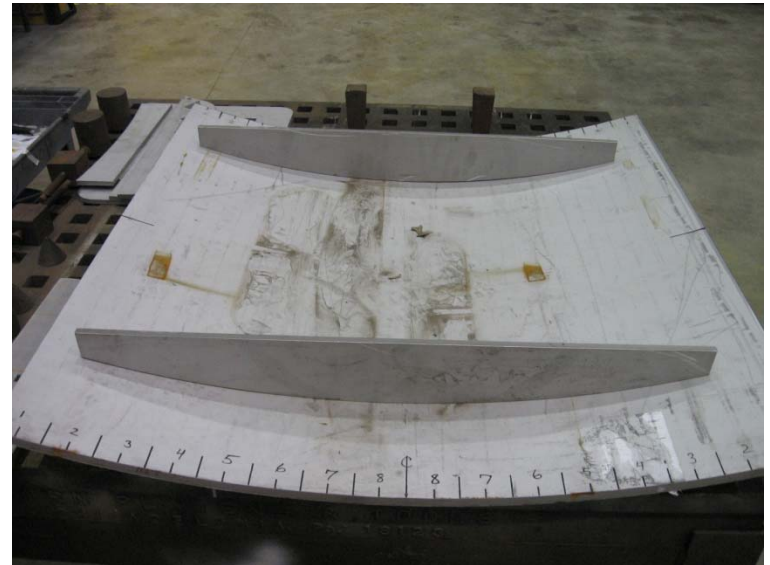
- Plasma Cutting
 - Gas-shielded plasma cutter
 - Rapid cutting maintains relatively low heat to bulk of vessel



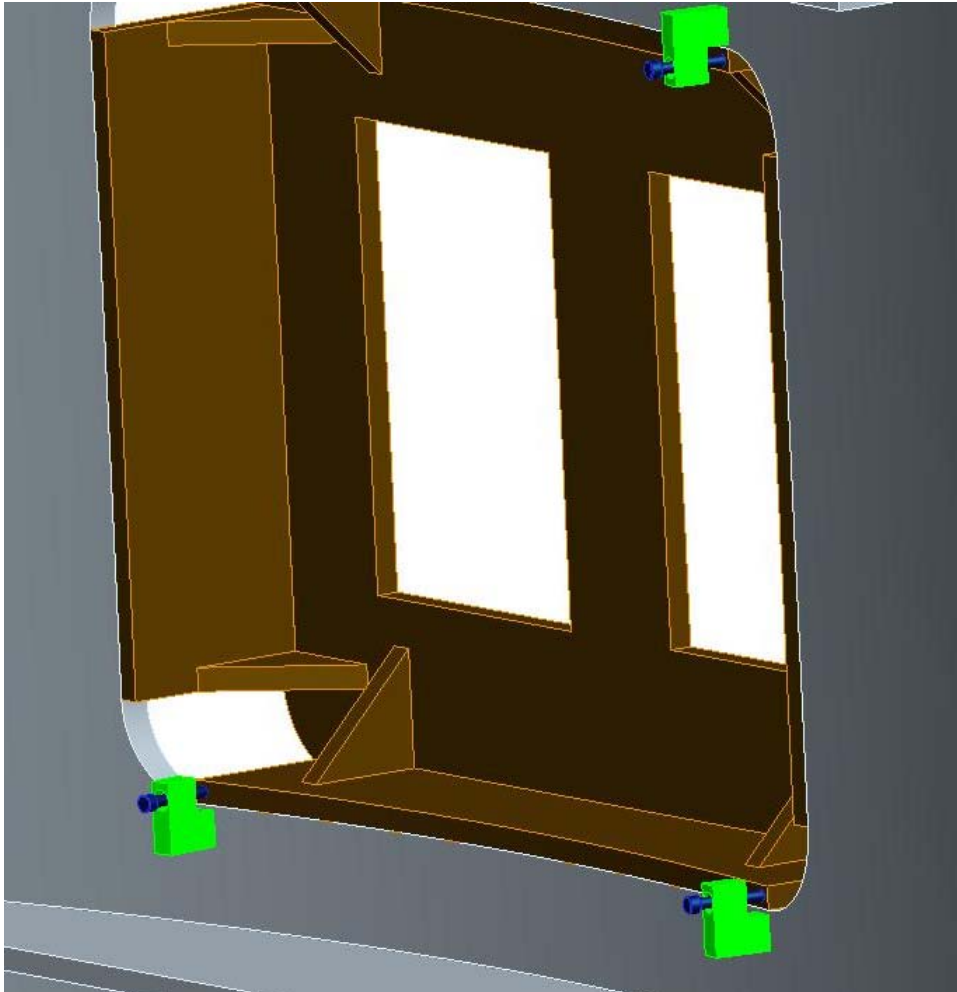
Plasma Cutter Offset



Cap Mockup



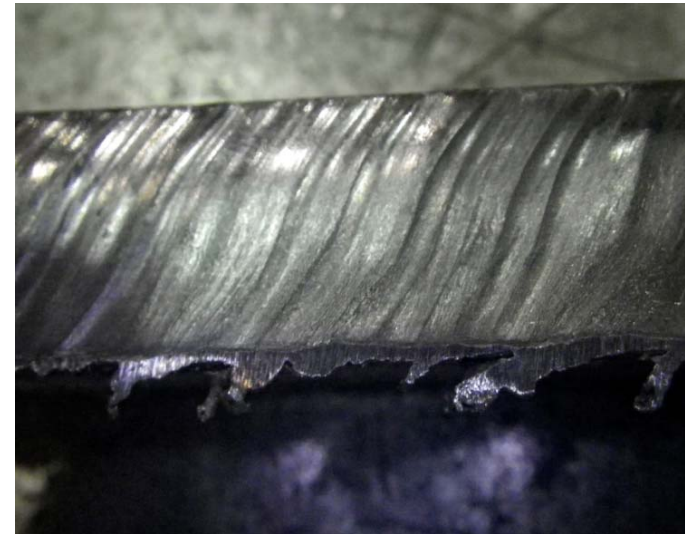
Cap Alignment Methodology



- Initial installation
 - Test fit cap and grind as needed for slip fit into opening
 - Use jack screw brackets to achieve desired alignment
 - Tack weld cap into place
 - Monitor alignment until fully constrained

Vessel Cutting

- Use guide for repeatable cut
- High speed, 2 ft long, 5/8" cut 304 SS
 - Similar to VV material completed in one minute
- Less than 1/16" ripple eliminated by grinding
- Containment system to be installed to catch debris
 - Sheet metal box with elephant trunk exhaust



Actual Vessel Cut



Vessel Cutting



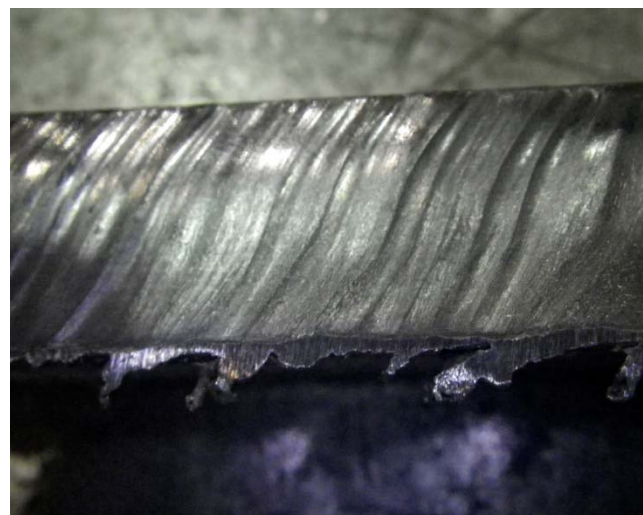
Raw Cut SST edge view



Raw Cut SST face view (1/32" scale)



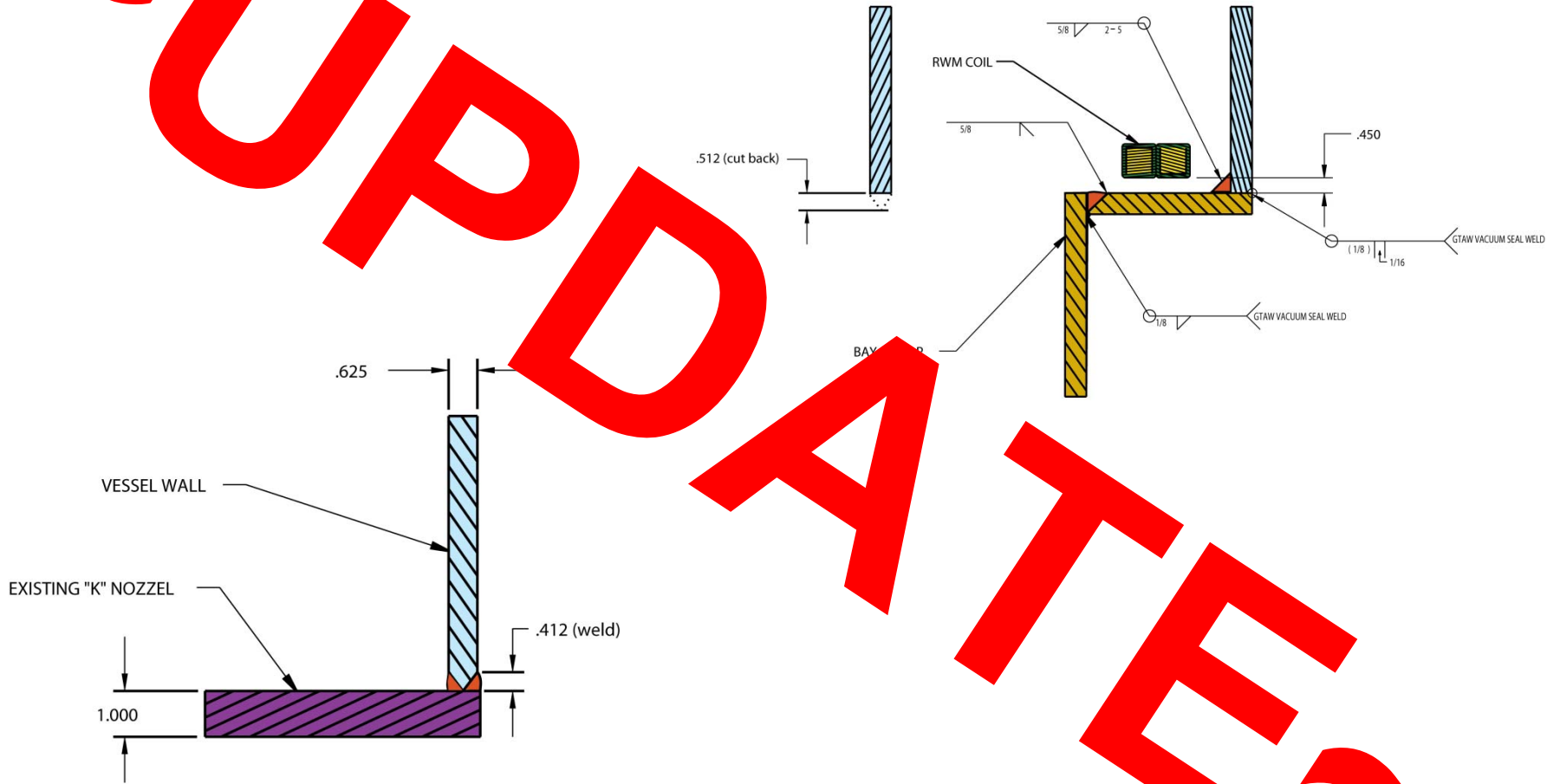
Wire brushing of cut



Resulting finish

Welding Joint Design

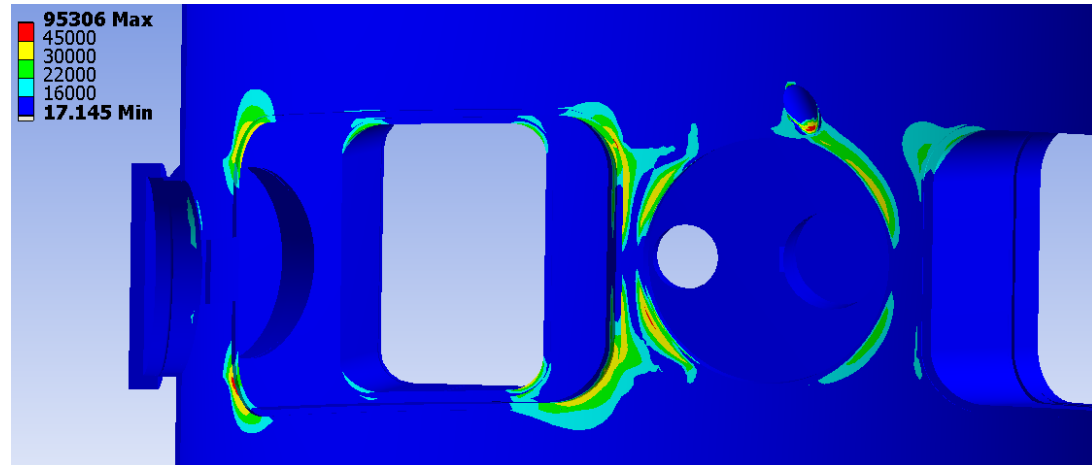
UPGRADE



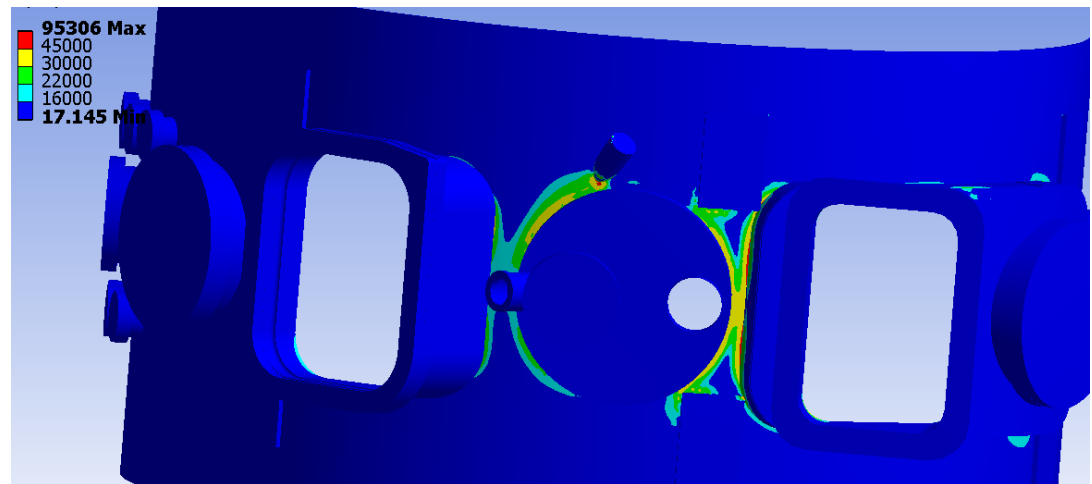
Flux Cored Welding



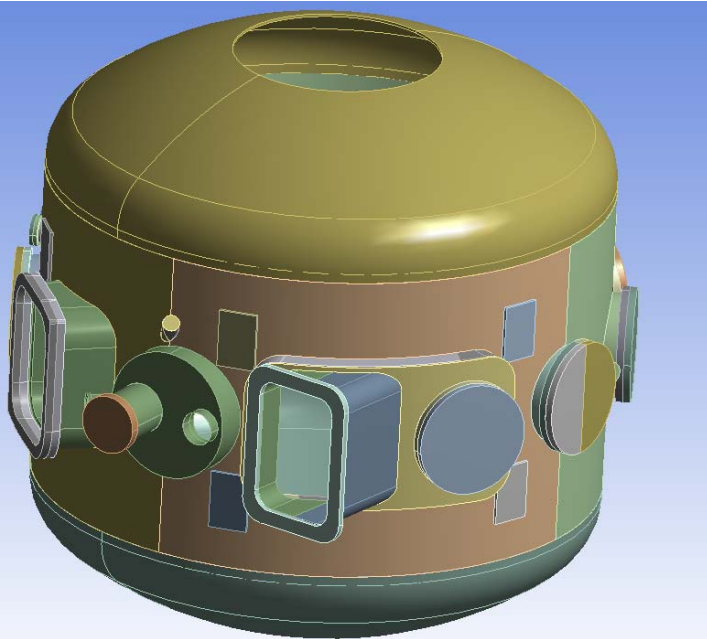
Vessel Reinforcement



Inside



Outside

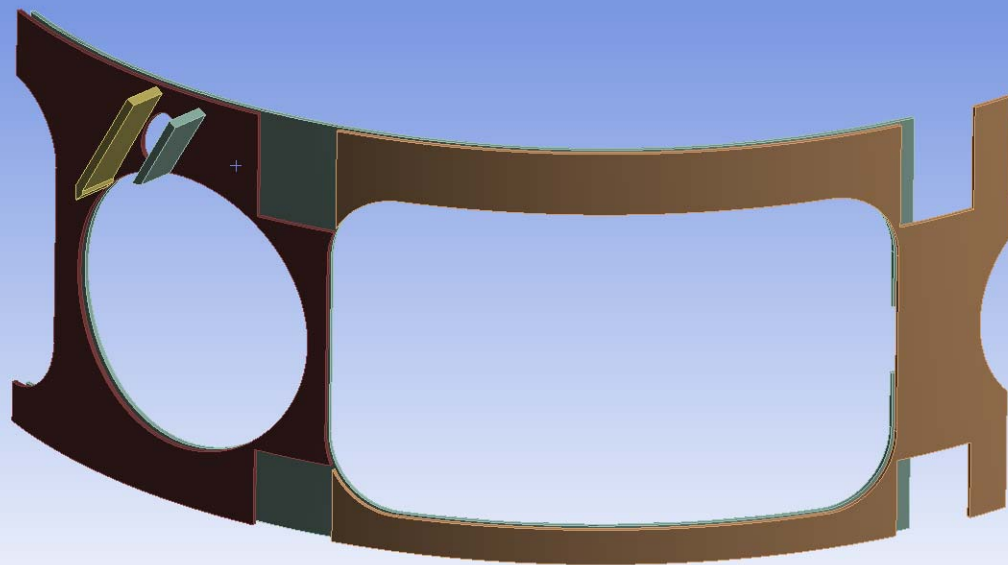


4/16/2011 4:41 PM

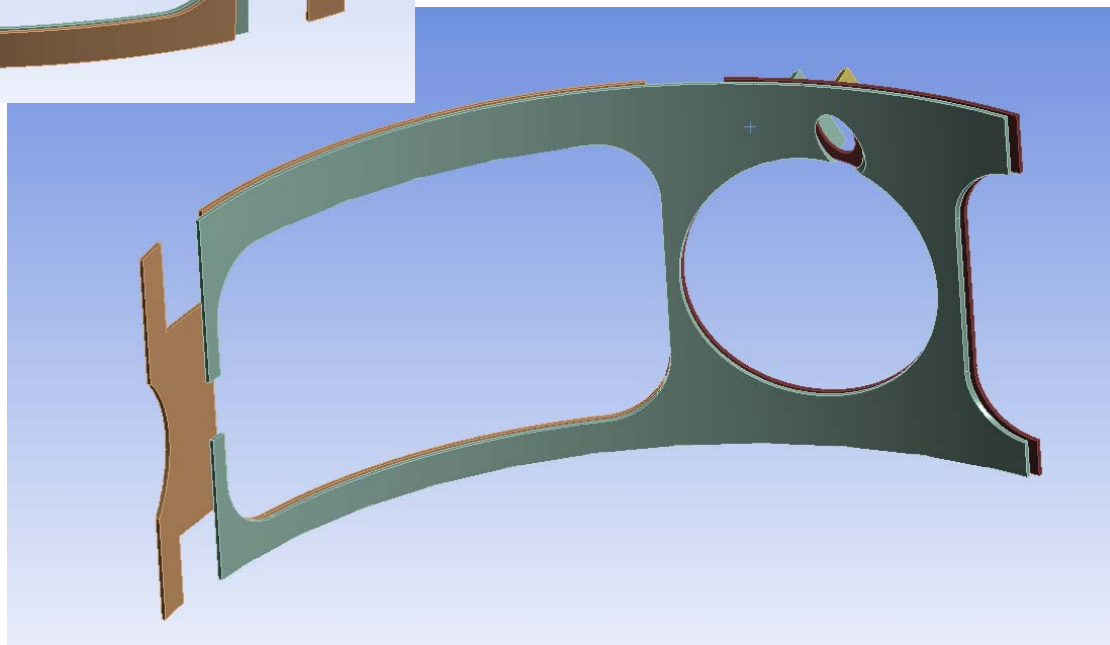
- A** Fixed Support
- B** Pressure: 14.7 psi
- C** Moment: 3.e+007 lbf in

Reinforcement Plates

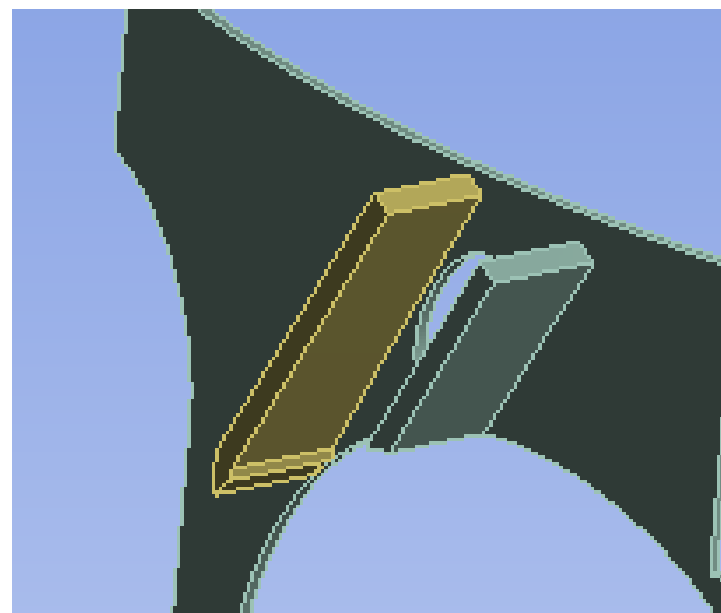
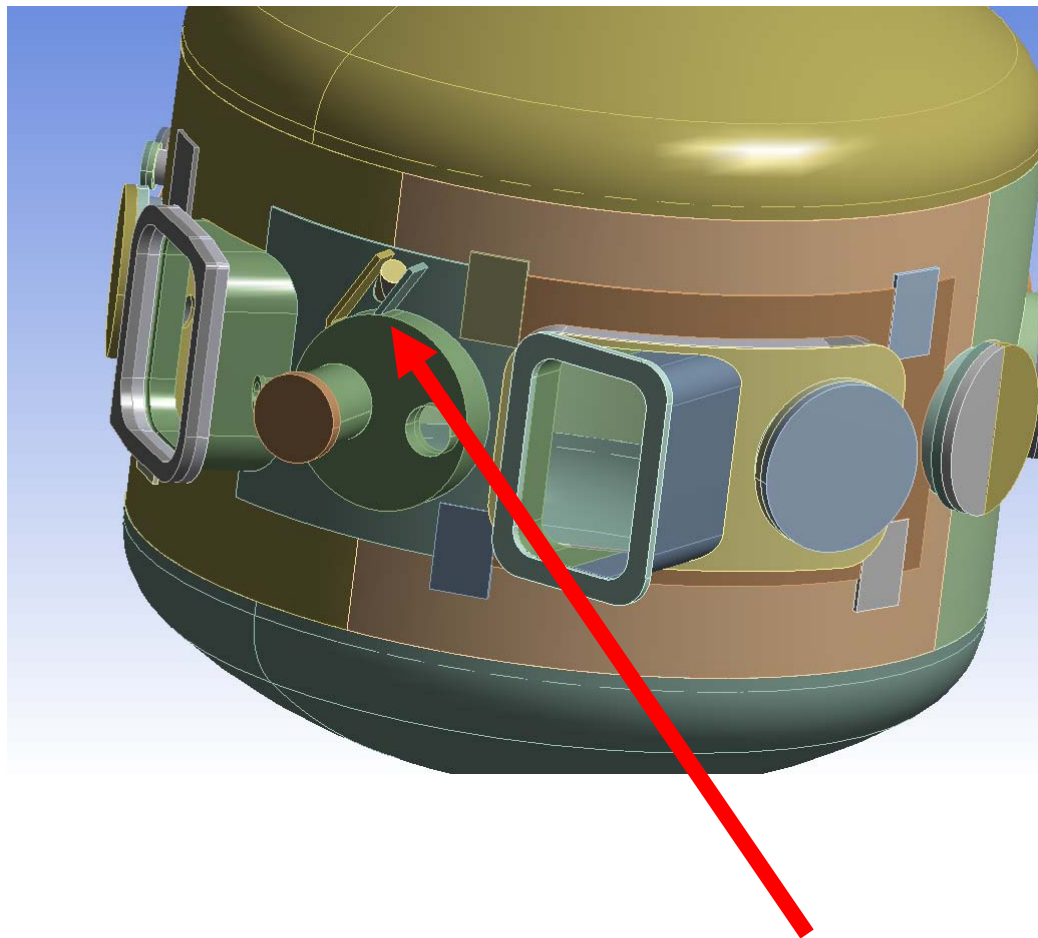
- 1/2" Thick
- Inside and outside



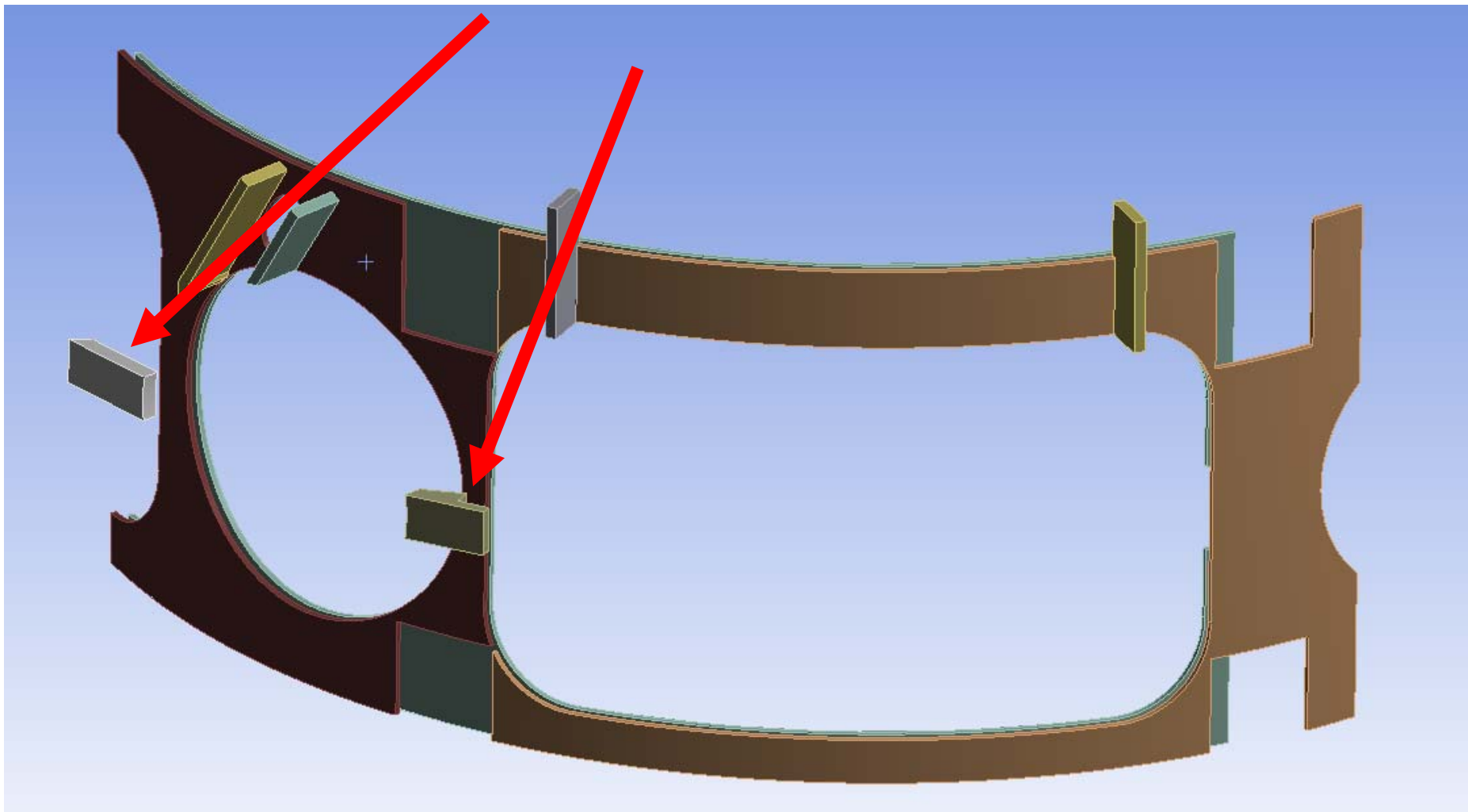
- Perimeter stitch welds
- Plug welds



Gussets around T-FIDA



Bolt on stiffeners between ports

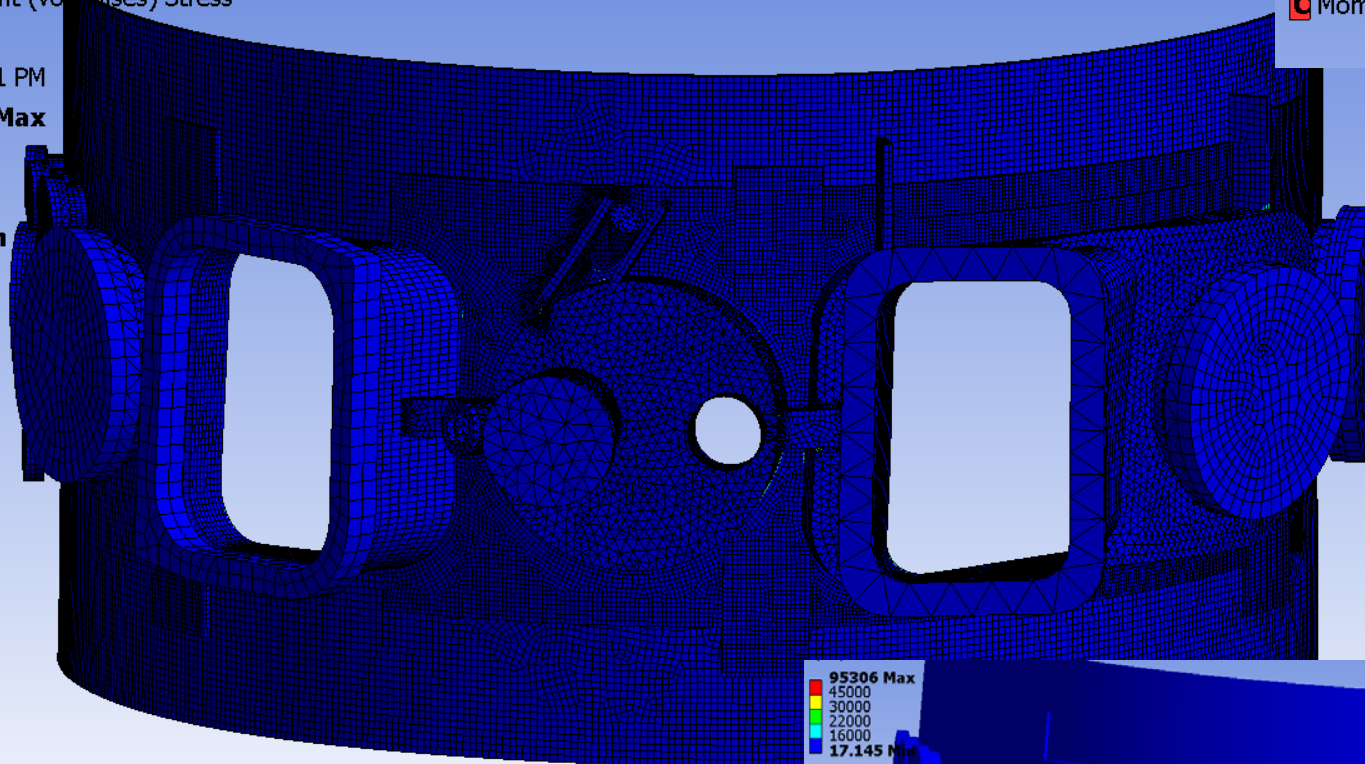


Pressure Load and Torque Load sc 79

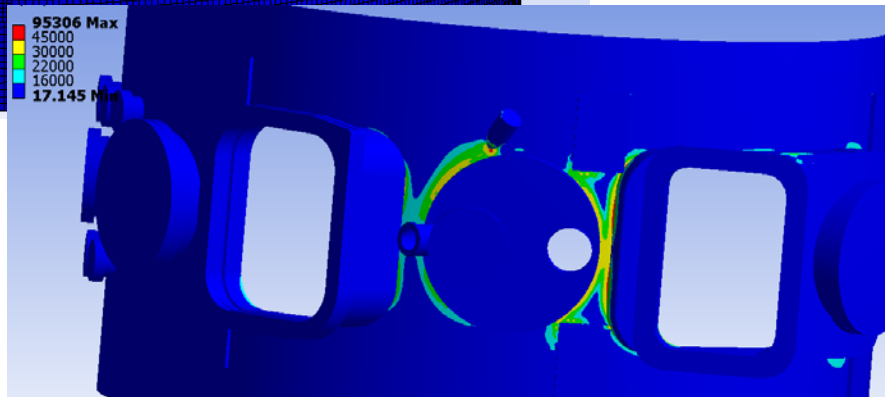
G: BL2, ETW, FG, IWT, Duct Gussets (DG)

Equivalent Stress
Type: Equivalent (von Mises) Stress
Unit: psi
Time: 1
Custom
4/16/2011 5:21 PM

1.1275e5 Max
71374
30000
22000
16000
14.822 Min



4/16/2011 4:41 PM
A Fixed Support
B Pressure: 14.7 psi
C Moment: 3.e+007 lbf in

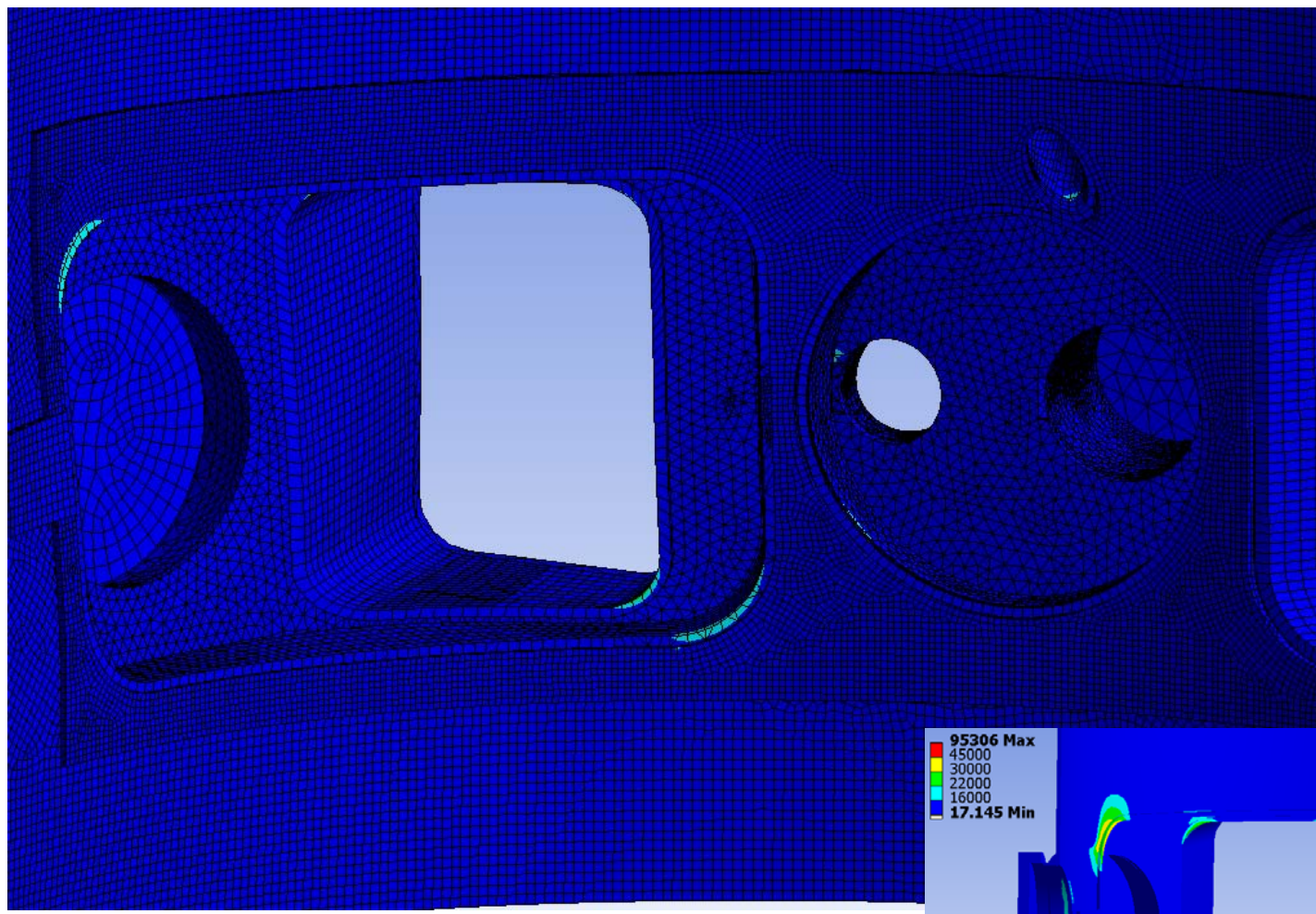


Outside

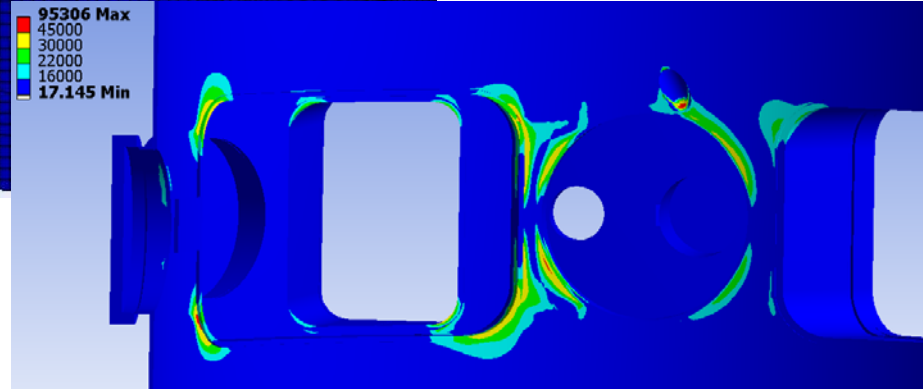
*** Add 6 ksi for Disruption ***

Pressure Load and Torque Load sc 79

4/16/2011 4:41 PM
A Fixed Support
B Pressure: 14.7 psi
C Moment: 3.e+007 lbf in



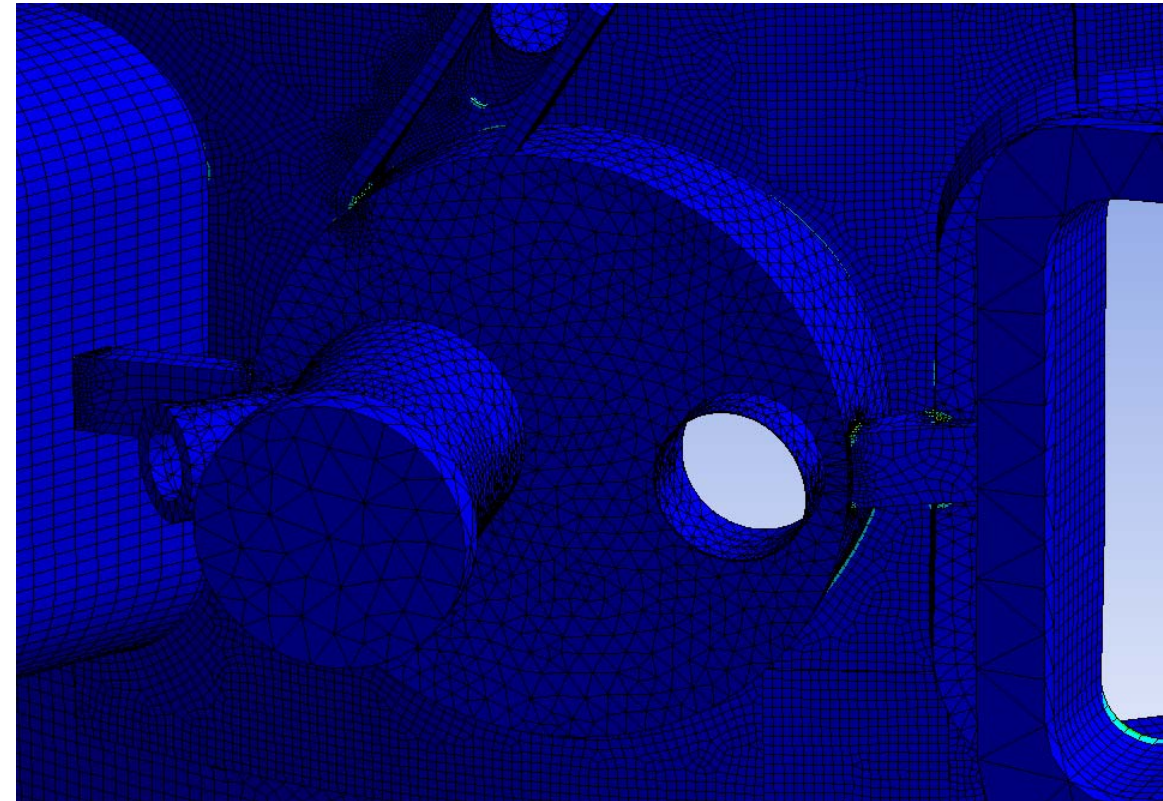
95306 Max
45000
30000
22000
16000
17.145 Min



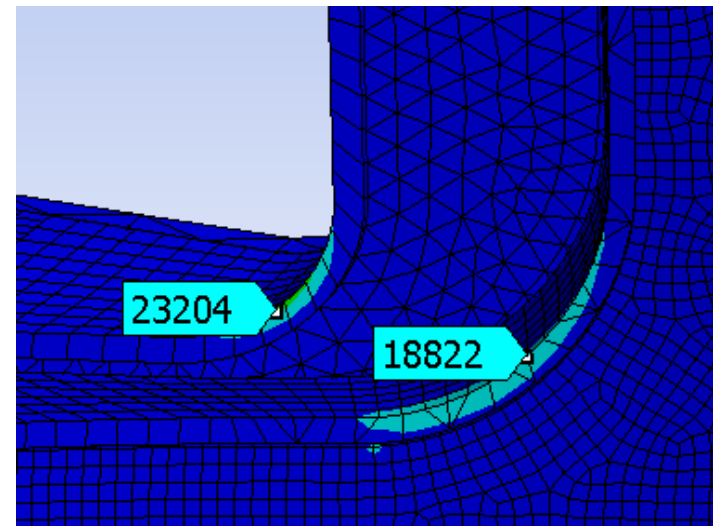
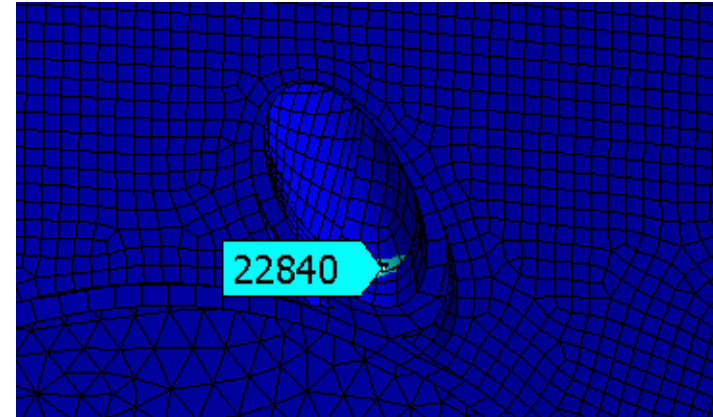
Inside

•• Add 6 ksi for Disruption ••

Pressure Load and Torque Load sc 79

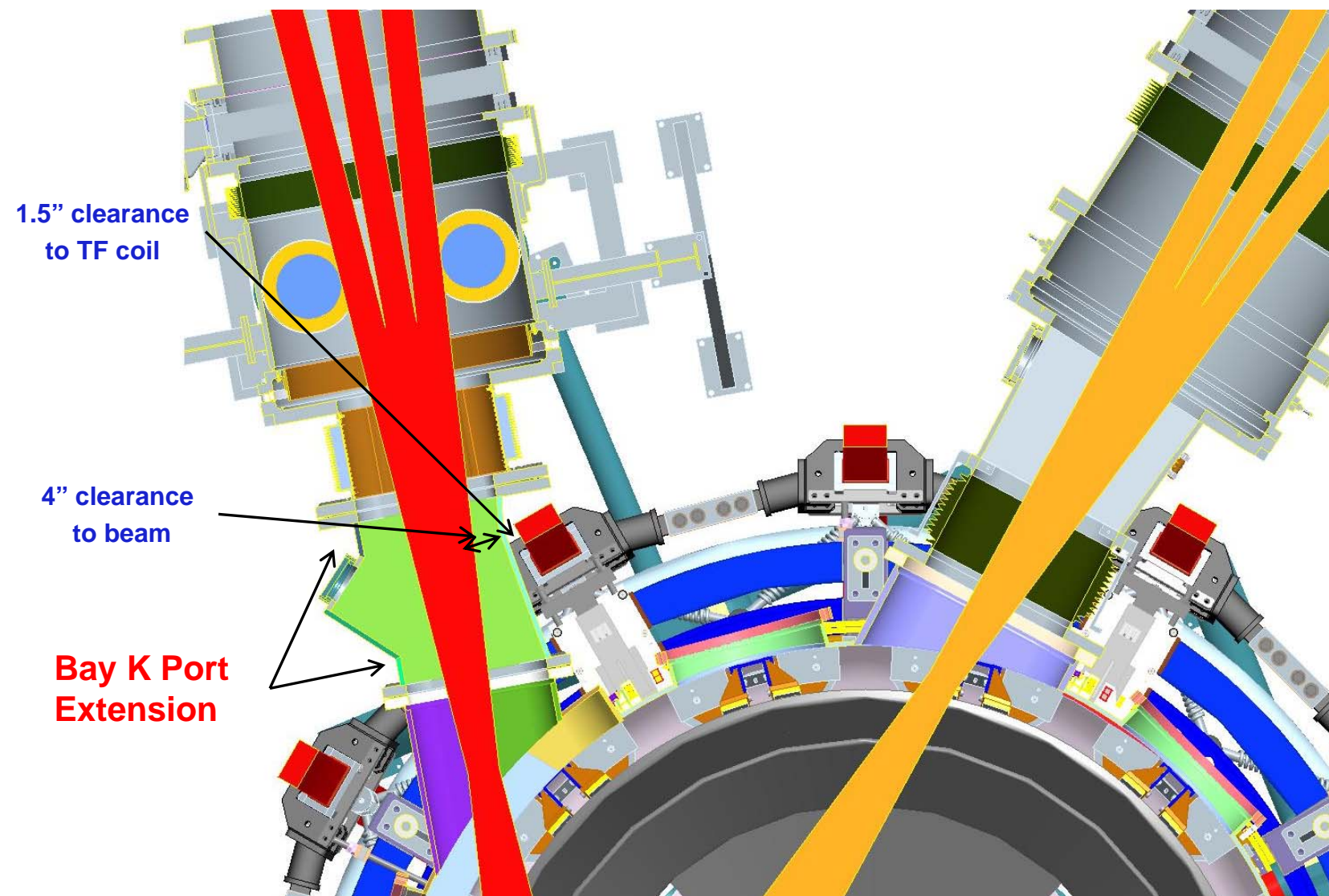


4/16/2011 4:41 PM
A Fixed Support
B Pressure: 14.7 psi
C Moment: 3.e+007 lbf in

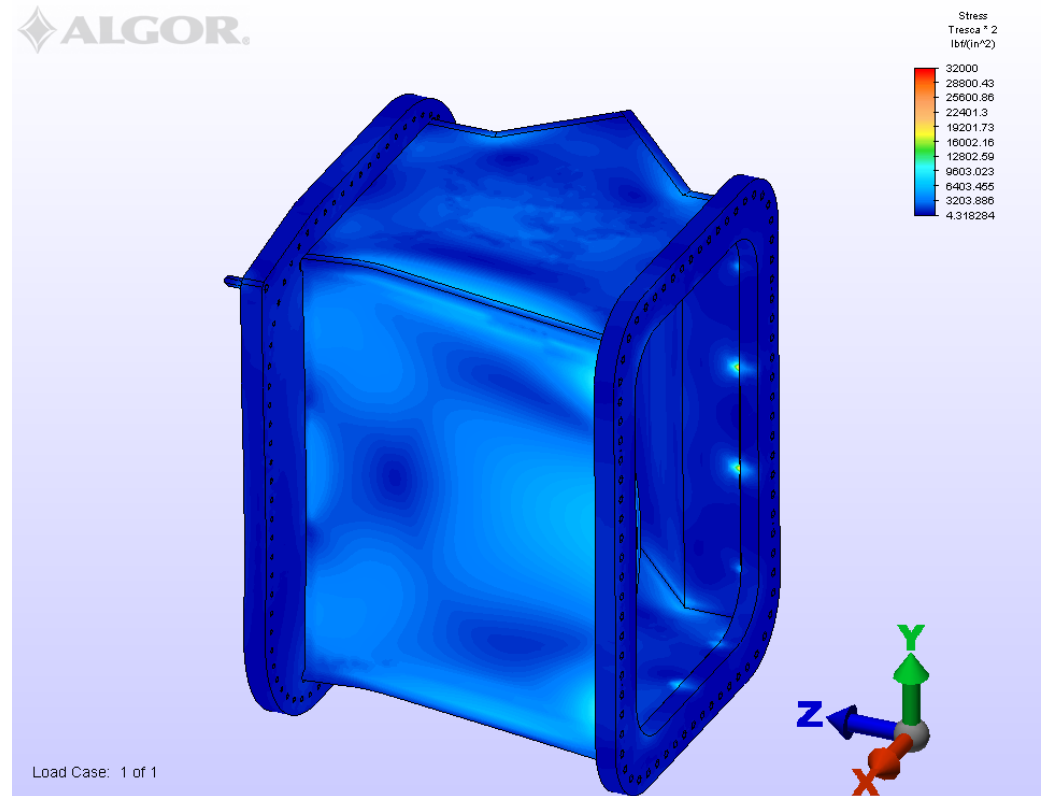
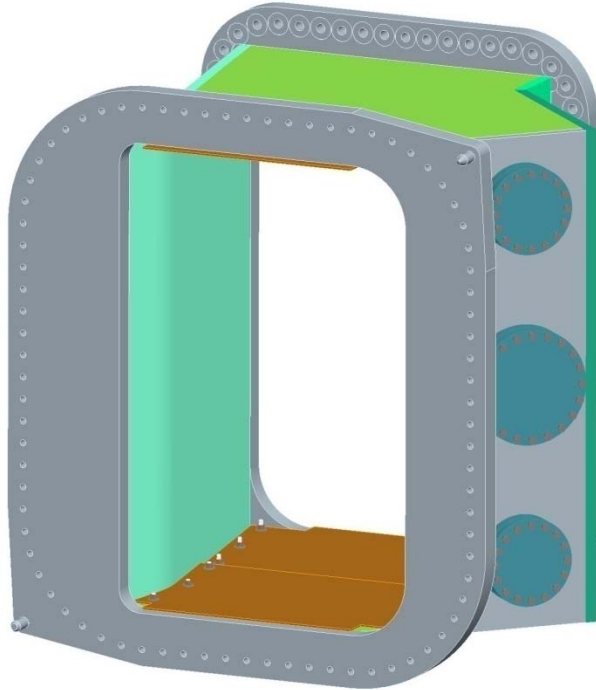


• ** Add 6 ksi for Disruption **

Port Extension Assembly



Port Extension Assembly

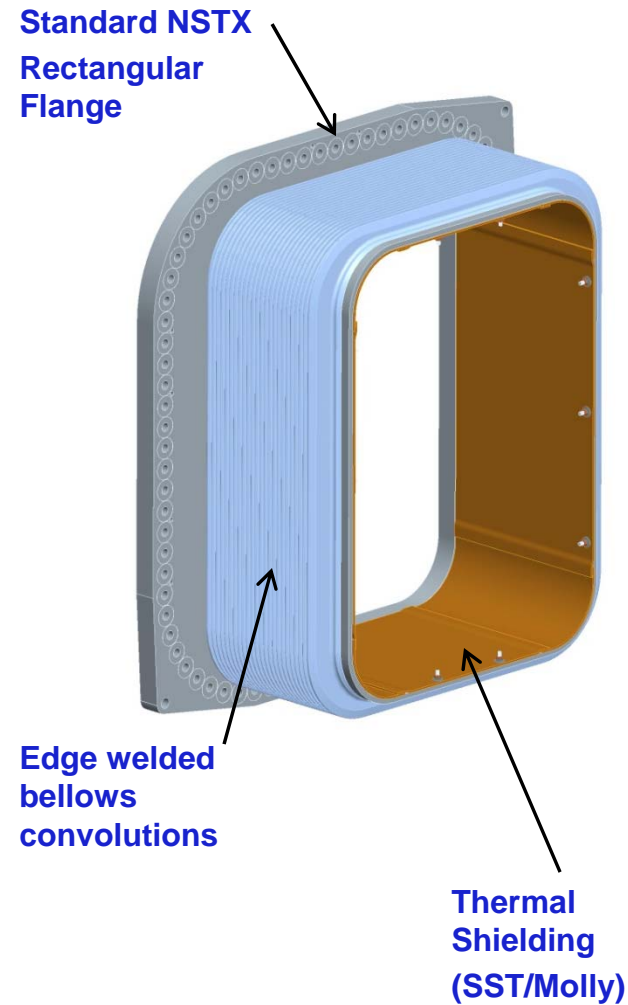


Vacuum Loads on Extension

Extension Features

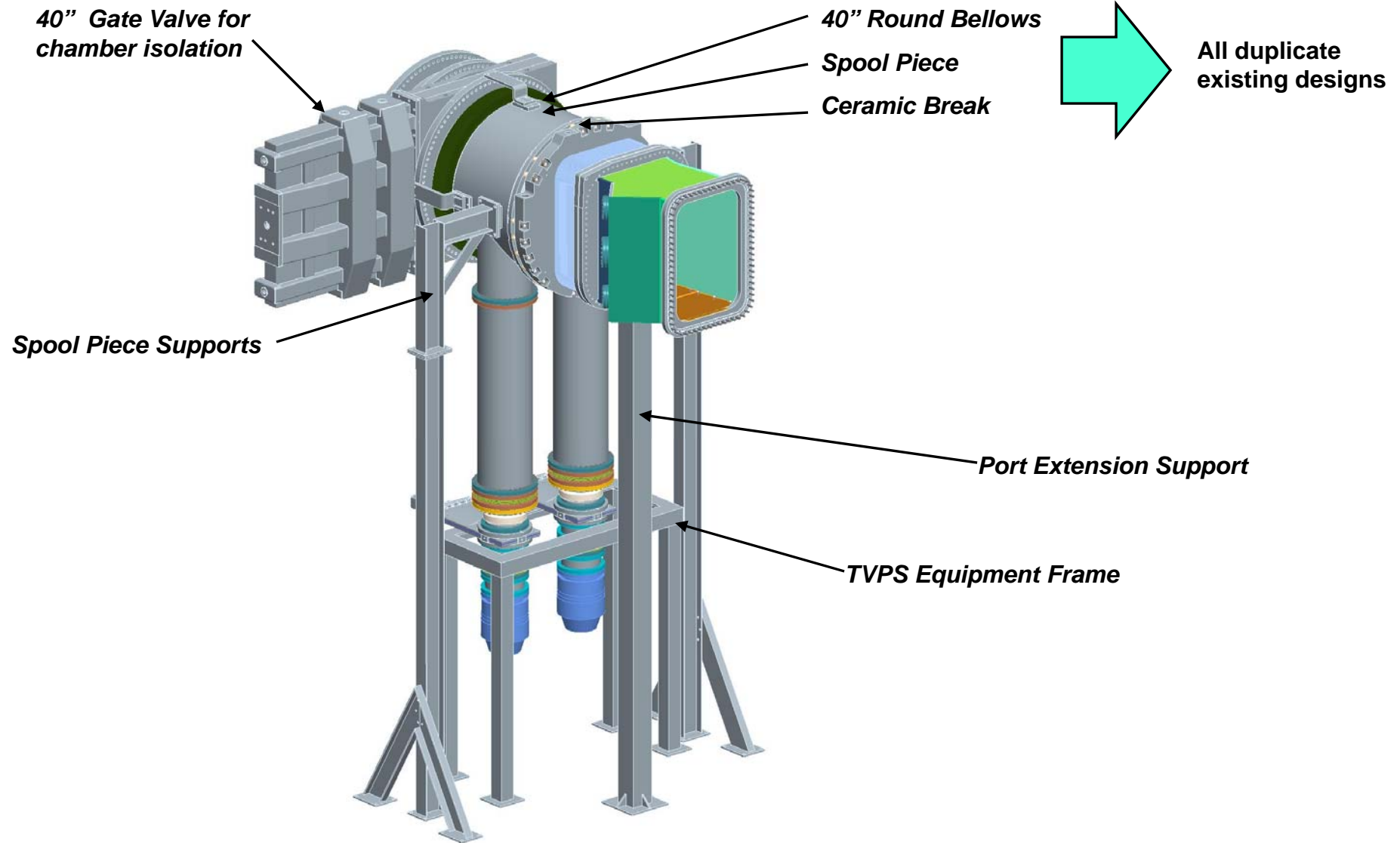
- Brings flanged interface out beyond TF coils
- Provides thin-profile vacuum boundary near coils
- Provides additional diagnostic ports

Rectangular Bellows Assembly



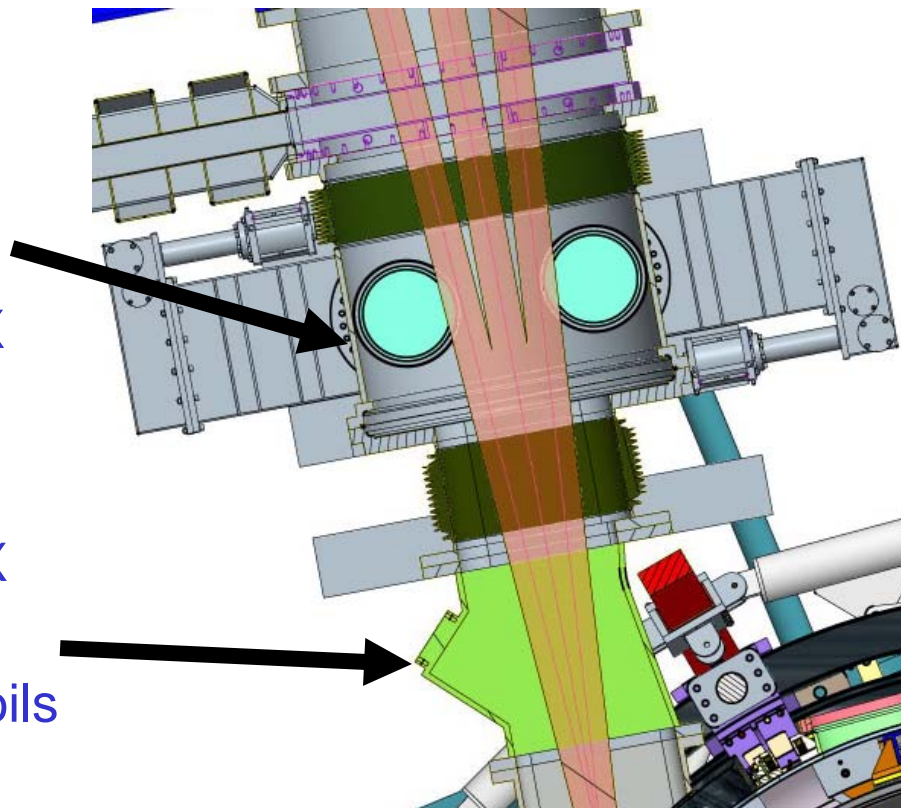
- Primarily to allow thermal growth of vessel ~0.30"
- On site fabrication of parts has started

Transition Duct Updates



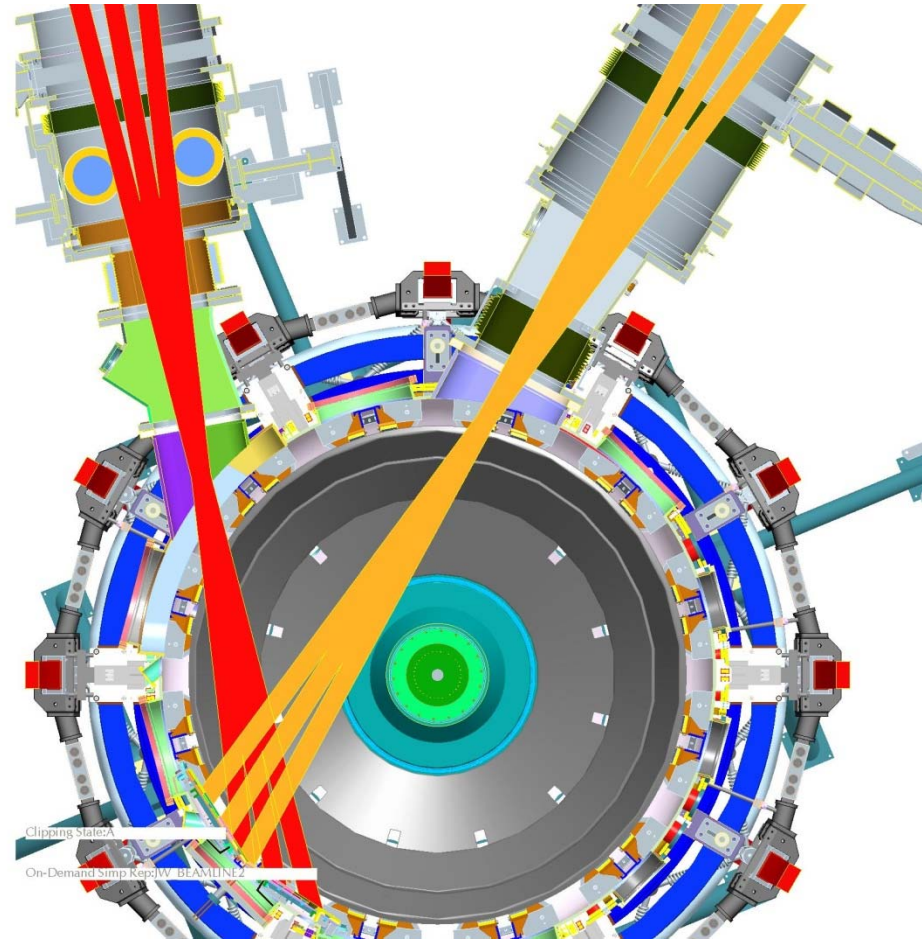
NB2 Transition Duct

- Transition Duct
 - Adapts from 1m TIV to NB rectangular flange
 - Contains bellows and ceramic break similar in design to NSTX NB1
- Port Extension
 - Permanently bolted up to NSTX
 - Extends NB2 Duct and Vessel Pump Duct interface past TF coils



Conclusion

- **Vessel Cap**
 - Installation solutions exist
 - Plasma Cutting
 - TF Coil removal Replacement
- **Beam Duct**
 - Internal molybdenum shielding added (greater protection than NB1)
 - Bellows Fabrication concerns alleviated
 - On-site fabrication of a spare

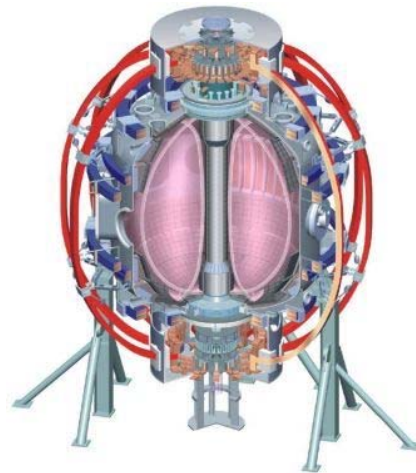


Questions?

NB Armor Install

K. Tresemer, M. Denault

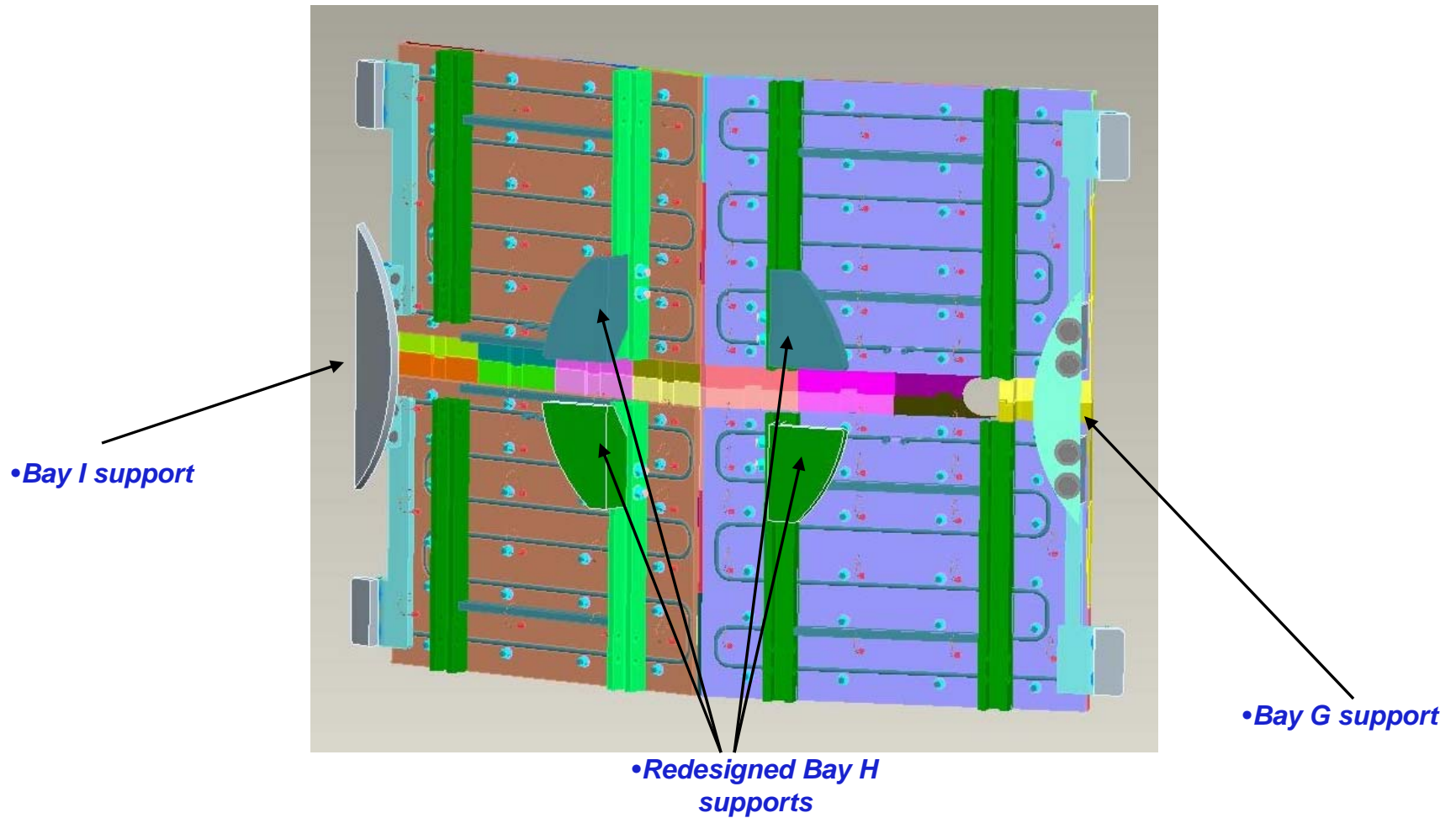
**NSTX Upgrade FDR
LSB, B318
June, 2011**



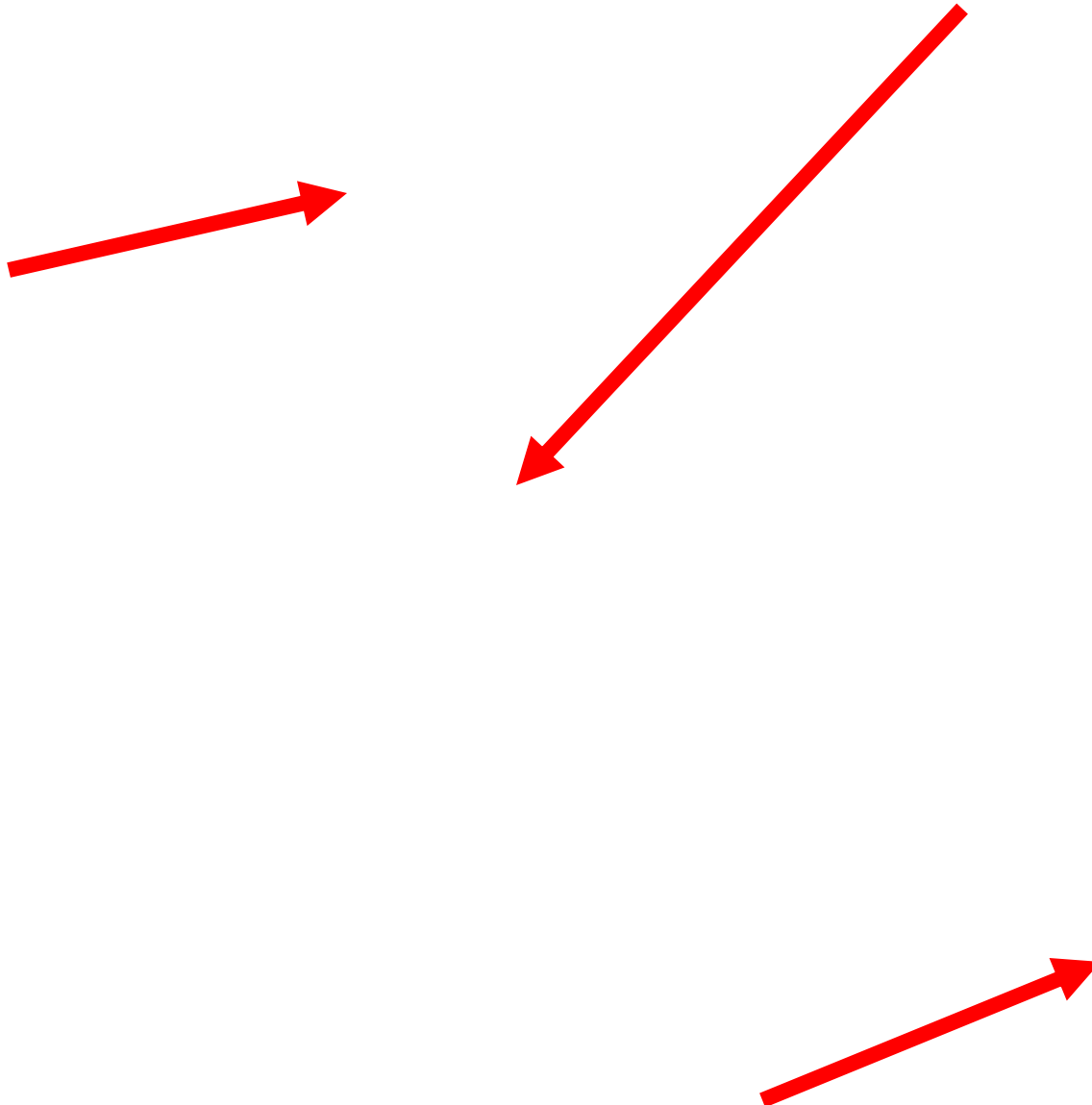
- College W&M
- Colorado Sch Mines
- Columbia U
- CompX
- General Atomics
- INEL
- Johns Hopkins U
- LANL
- LLNL
- Lodestar
- MIT
- Nova Photonics
- New York U
- Old Dominion U
- ORNL
- PPPL
- PSI
- Princeton U
- Purdue U
- SNL
- Think Tank, Inc.
- UC Davis
- UC Irvine
- UCLA
- UCSD
- U Colorado
- U Illinois
- U Maryland
- U Rochester
- U Washington
- U Wisconsin

- Culham Sci Ctr
- U St. Andrews
- York U
- Chubu U
- Fukui U
- Hiroshima U
- Hyogo U
- Kyoto U
- Kyushu U
- Kyushu Tokai U
- NIFS
- Niigata U
- U Tokyo
- JAEA
- Hebrew U
- Ioffe Inst
- RRC Kurchatov Inst
- TRINITY
- KBSI
- KAIST
- POSTECH
- ASIPP
- ENEA, Frascati
- CEA, Cadarache
- IPP, Jülich
- IPP, Garching
- ASGR, Czech Rep
- U Quebec

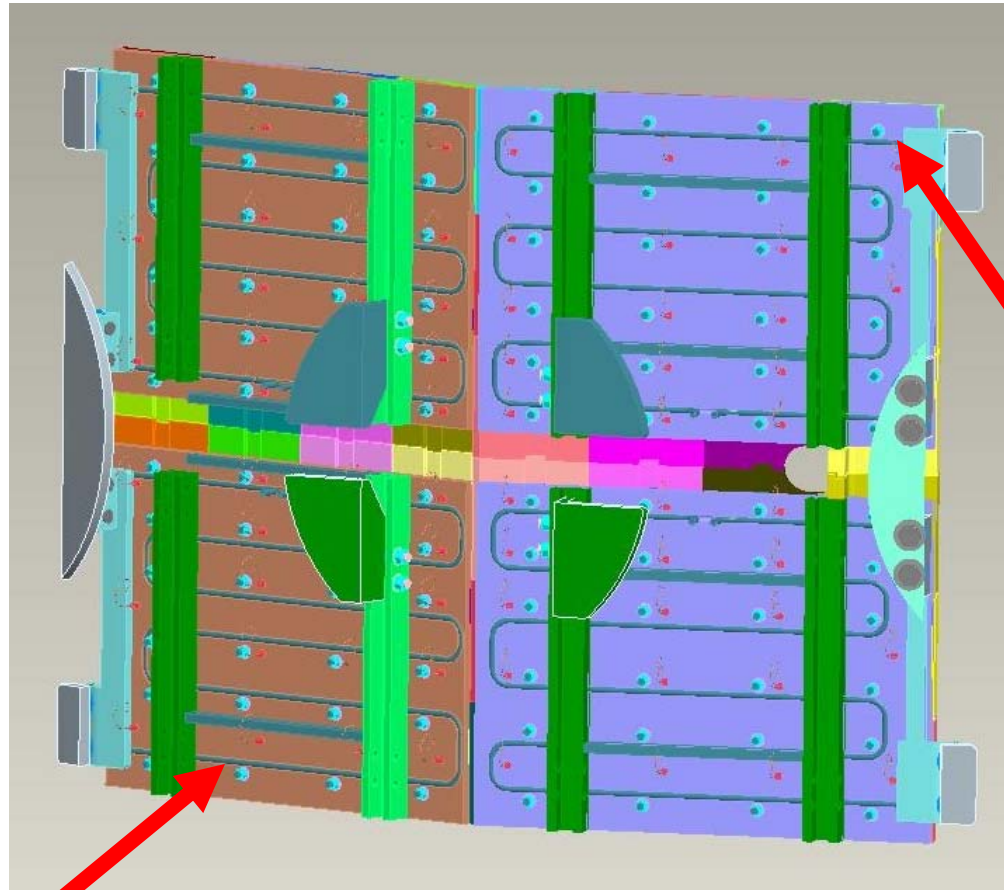
Armor Support System



Weldments



Cooling Lines and TC Wires out Bay H



Questions?

~fin~